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DRAFT REMEDIAL INVESTIGATION REPORT NORTH GRINDER LANDFILL OPERABLE
UNIT 1 (OU 1) NTC ORLANDO FL
4/1/1996
ABB ENVIRONMENTAL SERVICES, INC.

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**REMEDIAL INVESTIGATION REPORT
NORTH GRINDER LANDFILL
OPERABLE UNIT 1**

**NAVAL TRAINING CENTER
ORLANDO, FLORIDA**

Unit Identification Code (UIC): N65928

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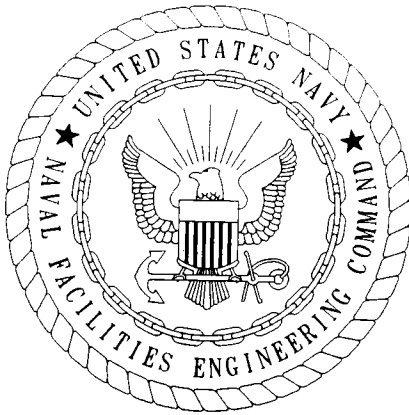
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April 1996



CERTIFICATION OF TECHNICAL
DATA CONFORMITY (MAY 1987)

The Contractor, ABB Environmental Services, Inc., hereby certifies that, to the best of its knowledge and belief, the technical data delivered herewith under Contract No. N62467-89-D-0317/107 are complete and accurate and comply with all requirements of this contract.

DATE: April 9, 1996

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(DFAR 252.227-7036)



FOREWORD

To meet its mission objectives, the U.S. Navy performs a variety of operations, some requiring the use, handling, storage, or disposal of hazardous materials. Through accidental spills and leaks and conventional methods of past disposal, hazardous materials may have entered the environment in ways unacceptable by today's standards. With growing knowledge of the long-term effects of hazardous materials on the environment, the Department of Defense (DOD) initiated various programs to investigate and remediate conditions related to suspected past releases of hazardous materials at their facilities.

One of these programs is the Base Realignment and Closure (BRAC) Cleanup Plan (BCP). This program complies with the Base Closure and Realignment Act of 1988 (Public Law 100-526, 102 Statute 2623) and the Defense Base Closure and Realignment Act of 1990 (Public Law 101-510, 104 Statute 1808), which require the DOD to observe pertinent environmental legal provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Executive Order 12580, and the statutory provisions of the Defense Environmental Restoration Program (DERP), the National Environmental Policy Act (NEPA), and any other applicable statutes that protect natural and cultural resources.

CERCLA requirements, in conjunction with corrective action requirements under Subtitle C of the Resource Conservation and Recovery Act (RCRA), govern most environmental restoration activities. Requirements under Subtitles C, I, and D of RCRA, as well as the Toxic Substances Control Act (TSCA), the Clean Water Act (CWA), the Clean Air Act (CAA), the Safe Drinking Water Act (SDWA), and other statutes, govern most environmental mission-related, operational-related, and closure-related compliance activities. These compliance laws may also be applicable or relevant and appropriate requirements (ARARs) for selecting and implementing remedial actions under CERCLA. NEPA requirements govern the Environmental Impact Analysis and Environmental Impact Statement preparation for the disposal and reuse of BRAC installations.

The BCP process centers on a single goal: expediting and improving environmental response actions to facilitate the disposal and reuse of a BRAC installation, while protecting human health and the environment.

The Southern Division, Naval Facilities Command (SOUTHNAVFACENGCOM), the U.S. Environmental Protection Agency (USEPA), and the Florida Department of Environmental Protection (FDEP) collectively coordinate the cleanup activities through the Orlando Partnering Team. This team approach is intended to foster partnering, accelerate the environmental cleanup process, and expedite timely, cost-effective, the environmentally responsible disposal and reuse decisions.

Questions regarding the BCP process at Naval Training Center (NTC), Orlando should be addressed to the SOUTHNAVFACENGCOM BRAC Environmental Coordinator (BEC) for NTC, Orlando, Mr. Wayne Hansel at (407)646-5294 or the Southern Division Engineer-in-Charge, Ms. Barbara Nwokike at (803)820-5566.

EXECUTIVE SUMMARY

The Navy has two programs to investigate and remediate conditions related to past releases of hazardous materials at their facilities. They are the Installation Restoration (IR) and Base Realignment and Closure (BRAC) programs. The IR program is conducted in several stages starting with a Preliminary Assessment (PA) which is followed by a site Inspection (SI). If needed, these initial studies are followed by a Remedial Investigation and Feasibility Study (RI/FS), and Remedial Design and Remedial Action (RD/RA).

The goal of the BRAC program is to expedite and improve environmental response actions to facilitate the disposal and reuse of a BRAC installation, while protecting human health and the environment. The BRAC program embraces the principles of the IR program, but is designed primarily as a vehicle for the transfer of former Navy property into the private sector in an environmentally responsible manner.

The first two stages of investigation at the North Grinder Landfill under the IR program (PA and SI) are represented by the Initial Assessment Study, completed by C.C. Johnson & Associates, Inc. (1985), and the Verification Study by Geraghty & Miller, Inc. (1986). The Initial Assessment Study (IAS) consisted of field inspections, personnel interviews, and a review of historical records and aerial photographs, resulting in the identification of nine potentially contaminated sites at NTC, Orlando, including the North Grinder Landfill.

The Verification Study consisted of the installation of four water table monitoring wells (one upgradient, and three downgradient locations) and analysis of groundwater samples from those wells. Samples were submitted for analyses for volatile organic compounds (VOCs), metals, pesticides and polychlorinated biphenyls (PCBs), and radionuclides (gross alpha and gross beta). One of the downgradient monitoring wells had an exceedance for arsenic (68 micrograms per liter [$\mu\text{g}/\ell$] vs. a Federal maximum contaminant level [MCL] of 50 $\mu\text{g}/\ell$). All four monitoring wells had elevated levels of gross radioactivity (gross alpha from 20 to 41 picocuries per liter (pCi/ ℓ) versus a Florida MCL of 15 pCi/ ℓ , and gross beta from 28 to 38 pCi/ ℓ).

This Remedial Investigation (RI) represents the third stage of study at the North Grinder Landfill and was conducted under the BRAC program. A workplan to conduct a remedial investigation and feasibility study was written and finalized by ABB Environmental Services, Inc. (ABB-ES) in March 1995. The workplan has incorporated concepts promulgated by the Superfund Accelerated Cleanup Model (SACM) program, developed by the U.S. Environmental Protection Agency to streamline and standardize environmental investigations. One of the concepts of SACM adopted for this investigation was the principle of the presumptive remedy. The presumptive remedy is a tool designed to ensure consistency in remedy selection and reduce the cost and time required to clean up similar types of sites. The presumptive remedy for municipal landfills begins with the assumption that the landfill will remain a landfill (i.e., removal is not an option that is considered) and that the only feasible alternative is containment, which includes:

- capping;
- leachate collection and treatment;
- landfill gas treatment, and;

- institutional controls.

The field investigation was designed to be as efficient as possible to effect a rapid data acquisition and evaluation process. To this end, investigators began with the understanding that it would not be possible to completely characterize the site with even a very large number of explorations and chemical analyses. The approach was to sufficiently characterize the site with a limited number of explorations and chemical analyses that would permit development and refinement of a conceptual model based on reasonable conclusions drawn from those data.

The field investigation started in March 1995 with a geophysical survey to determine the footprint of the landfill and locate any "hot spots" that might warrant source removal. Following the geophysics, a passive soil gas survey took place over the landfill footprint to evaluate the existing soil cover. Permanent soil vapor implants were installed around the perimeter of the landfill to monitor whether or not landfill gas migration was taking place. Direct push technology (DPT) surveys took place to screen more than 150 groundwater samples taken from strategic locations both up and downgradient from the landfill to facilitate the selection of permanent monitoring wells. Nine monitoring well clusters of three wells each (water table, intermediate depth, and base of surficial aquifer) were installed at locations upgradient, along the sides, and downgradient of the landfill. Five of the nine clusters were sited to evaluate two zones of minor VOC contamination in groundwater resulting from DPT screening studies. In addition, surface soil sampling at a frequency of one sample per acre took place over the landfill to evaluate the adequacy of landfill cover materials.

Surface soil and groundwater sampling analytical results have revealed two potential contaminant problems at the landfill:

- polyaromatic hydrocarbons (PAHs) in surface soils, and
- elevated radiological parameters in groundwater from several monitoring wells.

Surface soil analytical results revealed that out of a total of 14 samples, three adjacent samples in the east-central portion of the landfill had elevated levels of three PAHs. A human health risk evaluation indicates that the cancer risk from human exposure to these levels of contamination poses risks that are well within the levels of risk acceptable to the U.S. Environmental Protection Agency.

Of the 27 monitoring wells that were sampled, elevated gross alpha and gross beta were observed in two intermediate and three deep groundwater samples. All of the wells in question are adjacent to the mapped perimeter of the landfill. Resampling and reanalysis has confirmed the elevated radiological parameters, but has left certain data gaps which are discussed in Chapter 4, Nature and Extent of Contamination. A second resampling event for certain field parameters, and analysis for methane and volatile suspended solids in selected wells have led ABB-ES to conclude that the radiological activity is likely due to natural sources which are being mobilized by altered groundwater chemistry under the landfill and at its fringes.

Even though the radiological activity in certain intermediate and deep wells exceeds background levels measured in water table wells installed during the background study (ABB-ES, 1995a), the gross alpha levels observed are statistically in the same population as wells in the FDEP's data base within the St. John's River Water Management District (gross beta levels are in two different populations). With sufficient institutional controls in place (deed restrictions,

cover maintenance), future users of the property will not be exposed to groundwater with elevated radiological parameters, therefore, no risk will be incurred. A groundwater monitoring program of existing wells is recommended.

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1.0 INTRODUCTION

1.1 REGULATORY BACKGROUND AND PURPOSE. Several investigations have been performed at Naval Training Center (NTC), Orlando to assess and characterize potential contamination at the facility. These include the 1985 IAS (C.C. Johnson, 1985), the followup 1986 Verification Study (Geraghty & Miller, 1986), and a U.S. Environmental Protection Agency (USEPA) Hazard Ranking System II (HRS II) Scoring (ABB Environmental Services, Inc. [ABB-ES], 1992). Under BRAC, an Environmental Baseline Survey (ABB-ES, 1994a) and various site investigations have been completed (ABB-ES, 1995b, 1995c).

The North Grinder Landfill was identified in the IAS and designated Operable Unit 1 (OU 1) for the purposes of this remedial investigation (RI). The RI was conducted to:

- determine the nature and distribution of contaminants at the site,
- identify potential threats to public health or the environment posed by the potential release of contaminants from the site, and
- support the evaluation of potential remedial alternatives based on engineering factors, implementability, environmental and public health concerns, and costs during the feasibility study (FS).

For this investigation, the presumptive remedy of containment has been assumed. It was anticipated that additional technologies would need to be considered to meet overall remedial objectives for the site. Presumptive remedies are preferred technologies for common categories of sites, based on historical RI/FS investigations within the Superfund program. The presumptive remedy approach is one tool of acceleration within the Superfund Accelerated Cleanup Model (SACM), and is expected to ensure consistency in remedy selection and reduce the cost and time required to clean up similar types of sites.

At the North Grinder Landfill, the primary goal of this RI is to determine (1) if groundwater controls are needed to prevent groundwater migration, and (2) the

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type of cover that may be required to prevent exposure. To support decisions made as a result of this investigation, data has been acquired that will support a human health risk assessment, a qualitative ecological risk evaluation, and a feasibility study.

This RI report presents the results of these investigations.

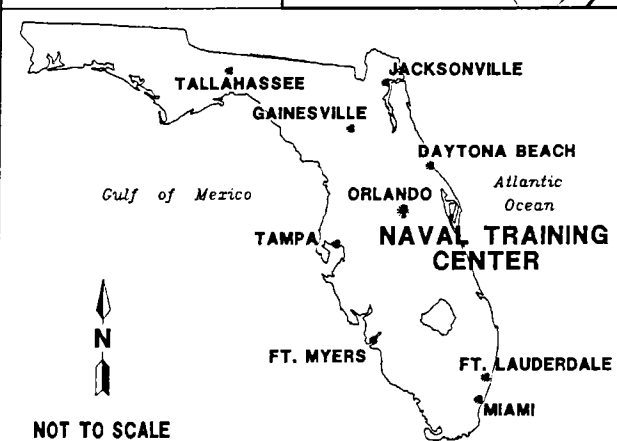
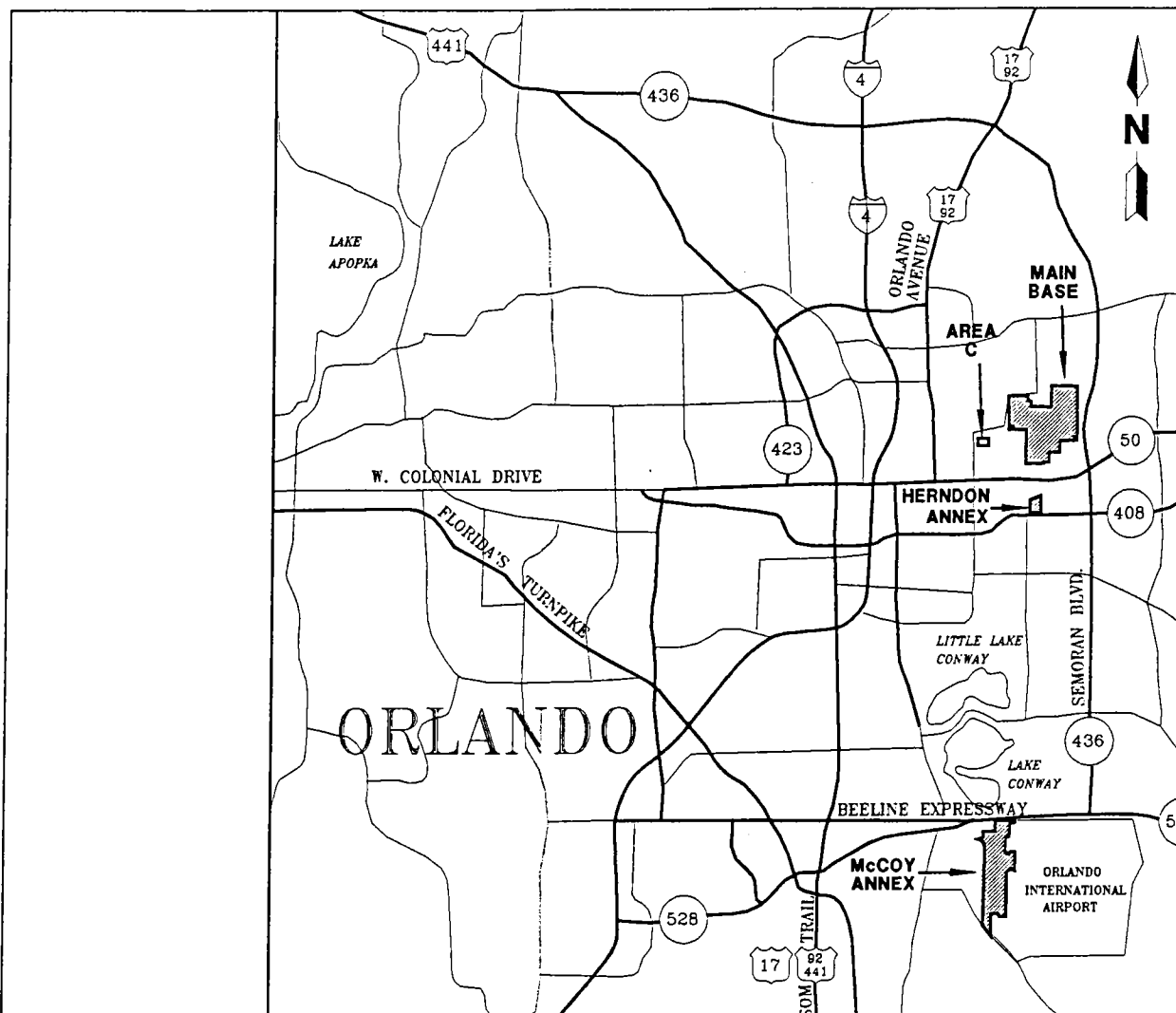
1.2 FACILITY BACKGROUND. OU 1 is located on the Main Base and was operated as a landfill from its beginnings possible as early as 1939 until it was closed in 1967. Further discussions of Area "C", Herndon Annex, and McCoy Annex may be found in the Project Operations Plan (POP) (ABB-ES, 1994b). (The remainder of this section is not included as it is considered nonessential for this submittal).

1.2.1 Facility History The history of NTC, Orlando dates to the construction of the original Orlando Municipal Airport prior to 1940. The U.S. Army Air Corps conducted operations at the Main Base and Area "C" from 1940 to 1947. In 1947, the U.S. Air Force assumed command of the facilities as the Orlando Air Force Base (OAFB).

The Navy began moving its Training Device Center from Port Washington, New York, to OAFB on September 15, 1965, and finished the move in June 1967. The property was commissioned as the Naval Training Center Orlando on July 1, 1968. The Main Base is comprised primarily of operational and training facilities. (The remainder of this section is not included as it is considered nonessential for this submittal).

1.2.2 Facility Description The following paragraphs address operations and surrounding land use for the Main Base.

Main Base operations constantly change, as various portions of NTC, Orlando gradually phase out activities. The Main Base is comprised primarily of operational and training facilities, including barracks, administrative buildings, drill fields, and recreational areas.



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SCALE: 1 INCH = 4 MILES

**FIGURE 1-1
VICINITY MAP**



**REMEDIAL INVESTIGATION
OPERABLE UNIT 1**

**NAVAL TRAINING CENTER
ORLANDO, FLORIDA**

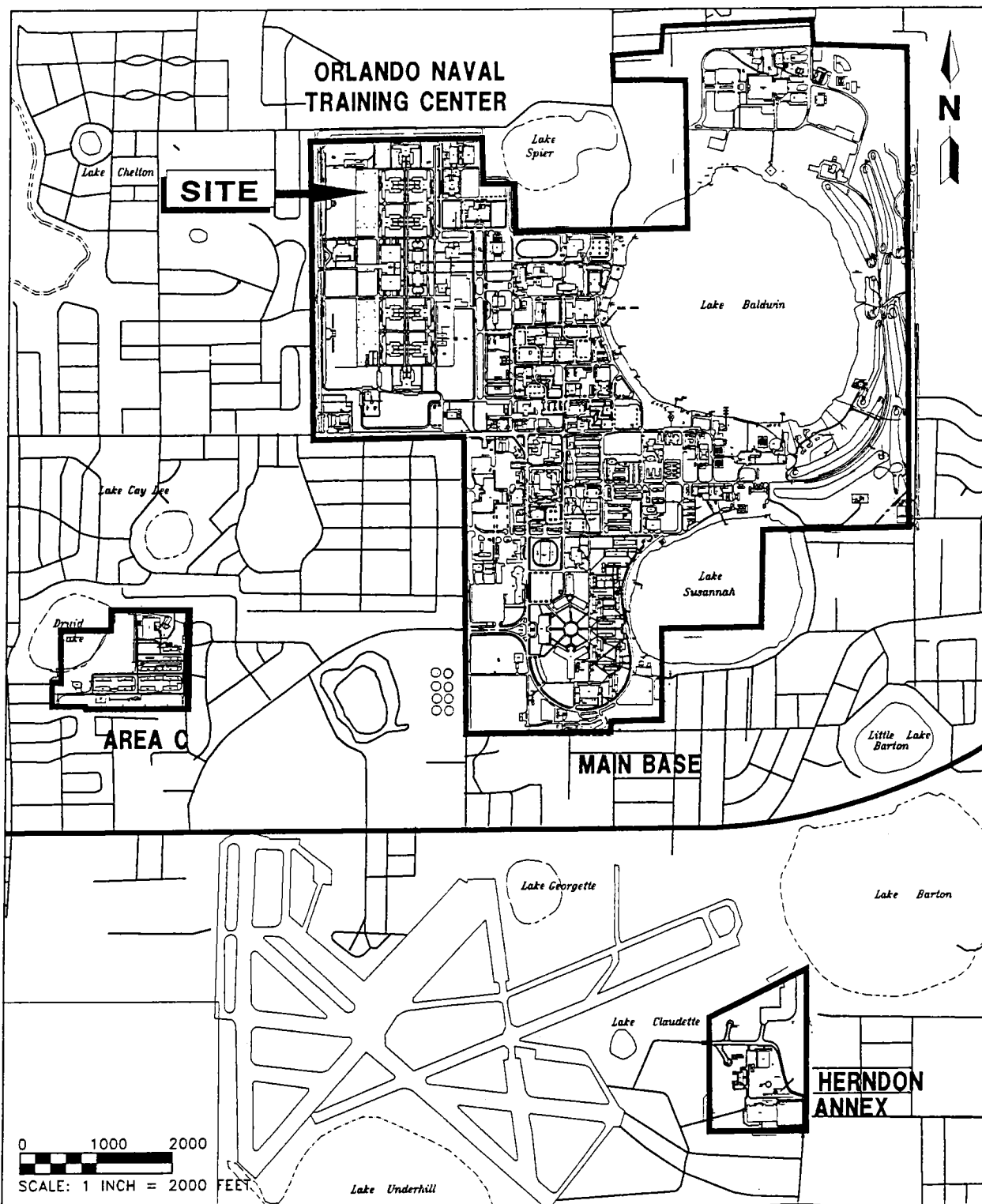


FIGURE 1-2
MAIN BASE, HERNDON ANNEX, AND AREA C
SITE LOCATION MAP



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The Main Base is surrounded by urban development, including single and multi-family housing, schools, and commercial buildings. Land uses directly west and northeast of the area are primarily residential. The Glenridge Elementary School is located on Glenridge Road, approximately 1,000 feet due north of OU1. Small areas of commercial development occur to the southwest.

The North Grinder Landfill (Figure 1-3) is located in the northwest corner of the Main Base and is under both lawn and an asphalt paved area known as the "grinder" parade area (there is also a South Grinder parade area that will be discussed below). The North and South Grinder parade areas are flat, although topography drops in elevation west, north, and east of the sites.

The North Grinder Landfill appears on aerial photographs as a southwest to northeast "slash" comprised of several trenches (Figure 1-4). Landfilling operations may have started sometime after 1939 and before 1947 (ABB-ES, 1996; 1994a). At that time, the property was wooded. Drawings from this era suggest that a camouflage demonstration area was also located in what is currently North Grinder, and may have contributed to the appearance of the aerial photographs. The landfill eventually encompassed a 15-acre area and was closed in 1967 prior to the construction of two dormitories, Buildings 212 and 214. During their construction, landfill materials were discovered, excavated, and backfilled before foundation structures were established. The disposition of excavated materials is unknown (ABB-ES, 1995d). Some pockets of landfill material may still exist, as base electrical shop personnel have reported observations of photographic film during excavation in the vicinity of Buildings 212 and 214 (ABB-ES, 1995e).

Figure 1-5 (U.S. Air Force, 1964) indicates that the North Grinder parade field not only was the site of a sanitary landfill, but also accommodated a fire-fighting training area and a skeet range. The fire-fighting training area was located approximately 450 feet south of present location of the training ship mock-up, Building 208, the USS Bluejacket. According to former base firefighters, the fire training area was used on a weekly basis from 1961 until 1965. Gasoline, diesel fuel, or oil were used to ignite the fires (ABB-ES, 1995e).

The skeet range was located at the present locations of Buildings 212 and 234.

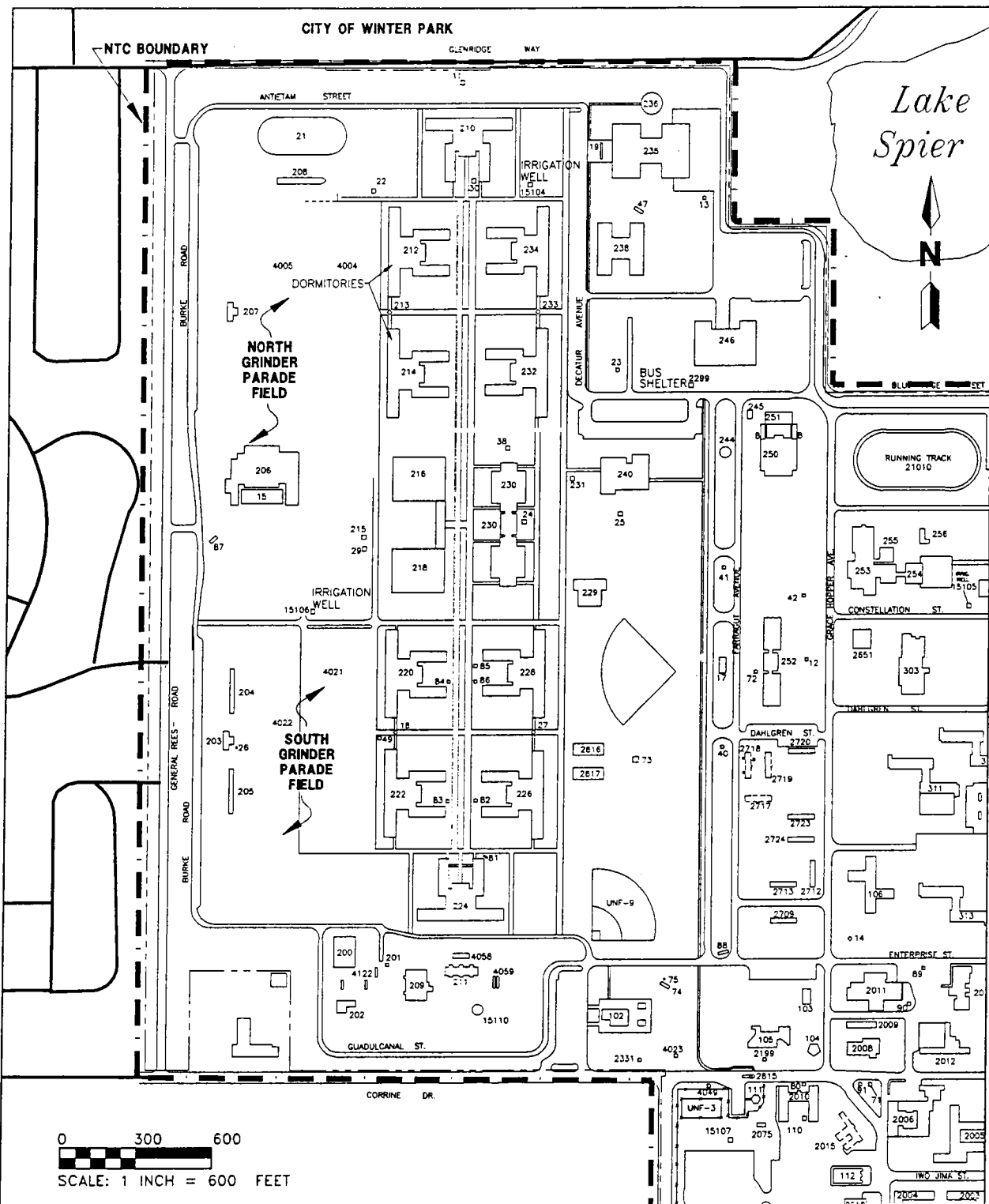
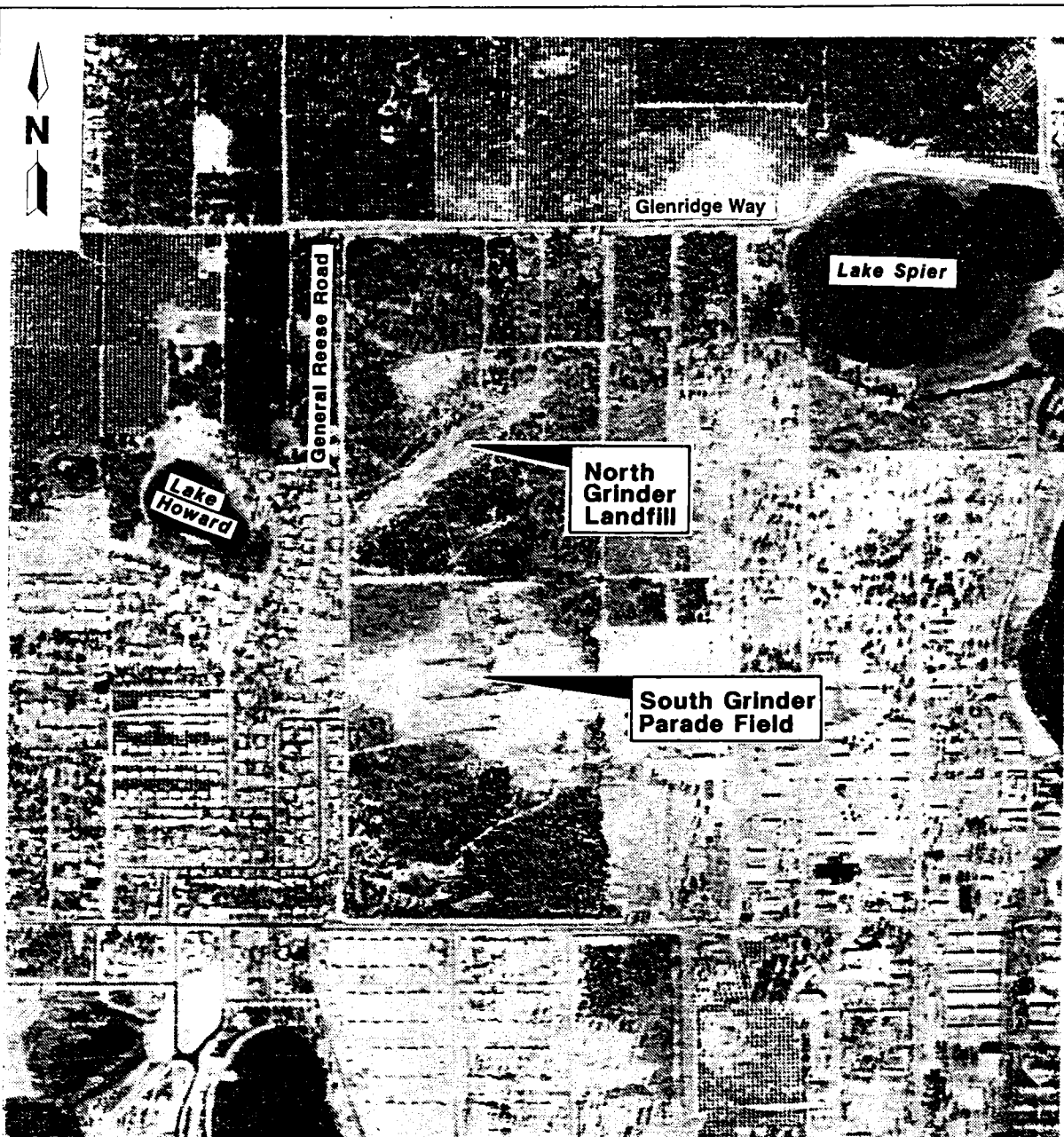


FIGURE 1-3
NORTH GRINDER AREA LOCATION MAP



**REMEDIAL INVESTIGATION
OPERABLE UNIT 1**

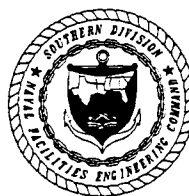
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Source: Pre-1962-vintage Air Force photograph

0 1000 2000
 APPROXIMATE SCALE: 1 INCH = 2000 FEET

FIGURE 1-4
AERIAL PHOTOGRAPH OF
NORTH AND SOUTH GRINDER AREAS



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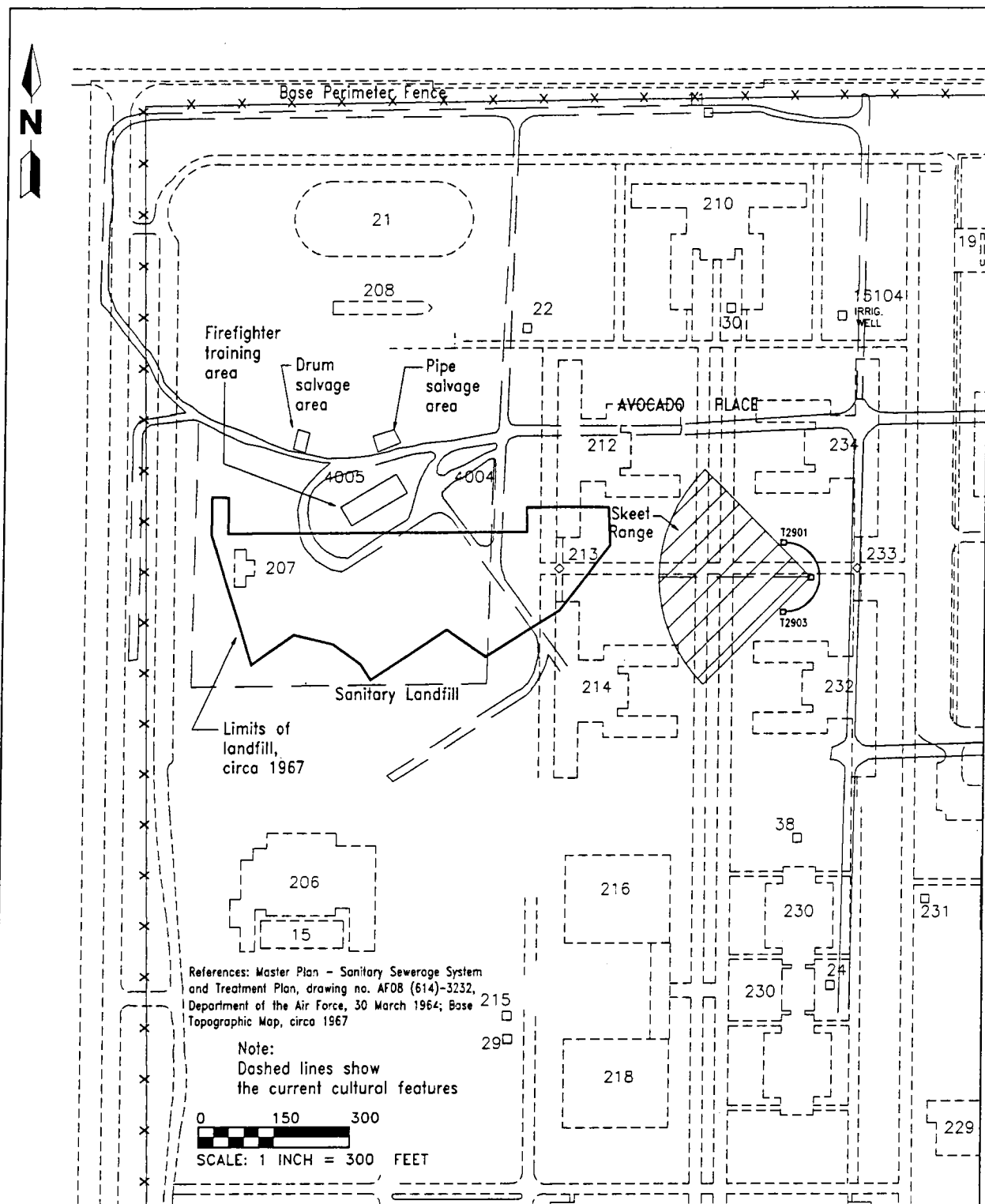


FIGURE 1-5
HISTORICAL MAP (1964 TO 1967) OF
NORTH GRINDER AREA



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The South Grinder parade area is located several hundred feet to the south and appears on at least one aerial photograph (Figure 1-4) as an area with sparse vegetation. Matador Missile test firing cells on the east side of the South Grinder parade area may account for some vehicular activity in the area, but landfilling activity is certainly a possibility given past disposal practices at NTC, Orlando. This possibility was addressed during the geophysical investigations discussed in Chapter 2.

1.3 PREVIOUS INVESTIGATIONS. The first phase of the IR program at NTC, Orlando was the IAS conducted in 1985 (C.C Johnson, 1985). This program included an archival search and site walkovers at all four facilities of NTC, Orlando. Nine potentially contaminated sites were identified, including OU1 (then designated Site 1). Of the nine sites, five were recommended for further investigation in a Verification Study. OU1 was included in this recommendation.

In 1986, the Verification Study was performed by Geraghty & Miller (Geraghty & Miller, 1986). The Verification Study included the installation and sampling of four shallow monitoring wells at OU1.

The results of these previous investigations are discussed in further detail below.

1.3.1 Initial Assessment Study The Initial Assessment Study (C.C. Johnson and Associates, 1985), estimated that the volume of waste was landfilled at OU1 was 194,000 cubic yards. Approximately 1/3 of this volume was excavated during construction of Buildings 212 and 214 in 1967. Landfill wastes reportedly included the following:

- film;
- photographic chemicals;
- paint thinner;
- garbage from mess halls;
- cardboard boxes, paper, and plastic;
- biological wastes and syringes from hospital;
- tree limbs and construction materials; and

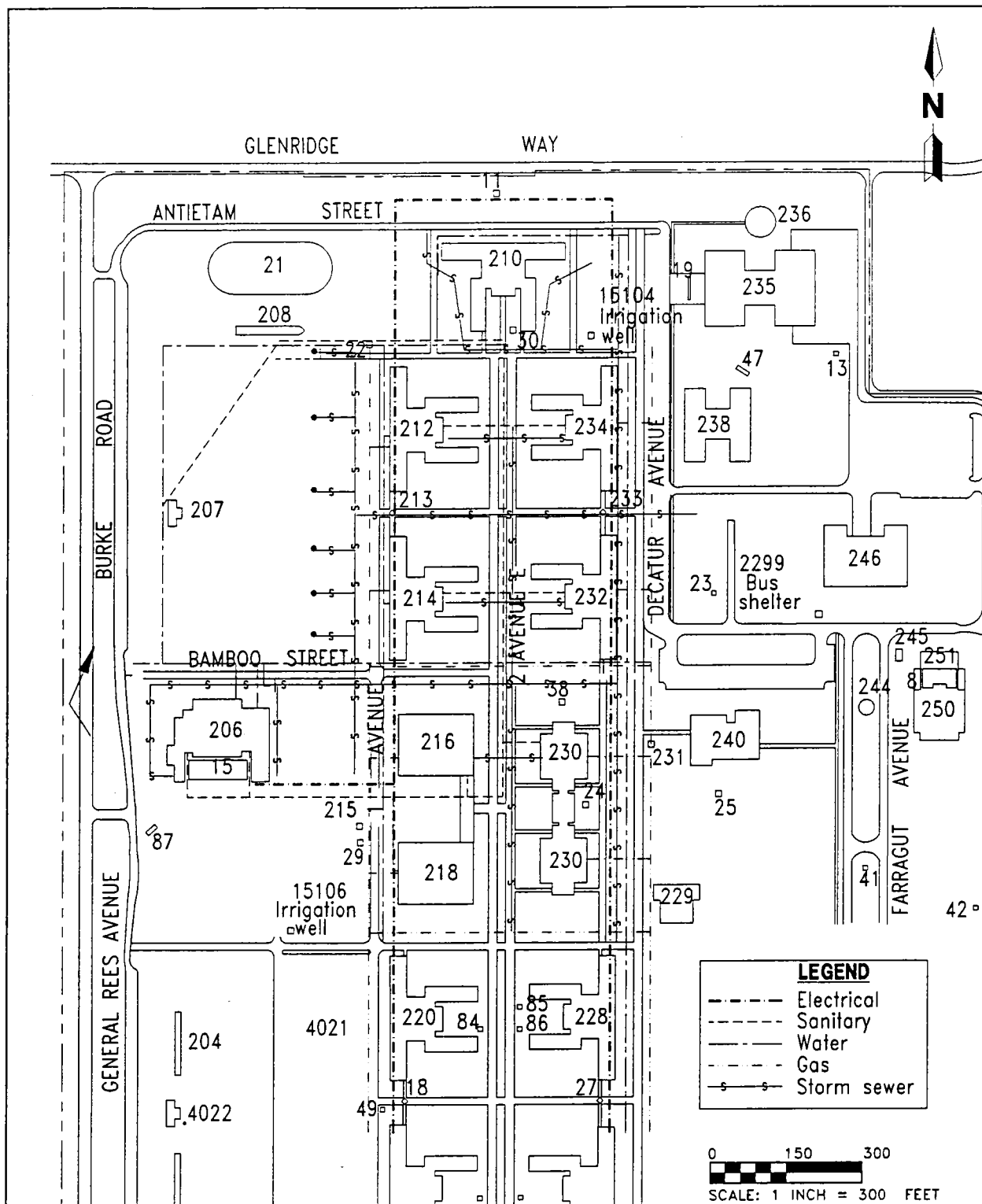


FIGURE 1-6
UTILITY LOCATION MAP



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- perchloroethylene (PCE) stillbottoms from laundry (stillbottoms are residues, or sludges, from dry cleaning operations, which use PCE as a cleaning agent).

Based on this information the North Grinder Area (designated Site 1 in the IAS) was recommended for further investigation in a Verification Study.

1.3.2 Verification Study Four shallow monitoring wells (Figure 1-7) were installed around the perimeter of OUI during the Verification Study (Geraghty & Miller, 1986). Groundwater samples were collected for analysis of USEPA priority pollutants, including volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides and polychlorinated biphenyls (PCBs), metals, cyanide, and total radiological activity (gross alpha and gross beta). A summary of the results is presented in Table 1-1.

These results indicate exceedances of Florida Maximum Contaminant Levels (MCLs) for arsenic and gross alpha radionuclides. The shallow wells installed during the Verification Study may not have been deep enough to detect a potential plume of PCE. Based on these considerations, OUI was recommended for a remedial investigation.

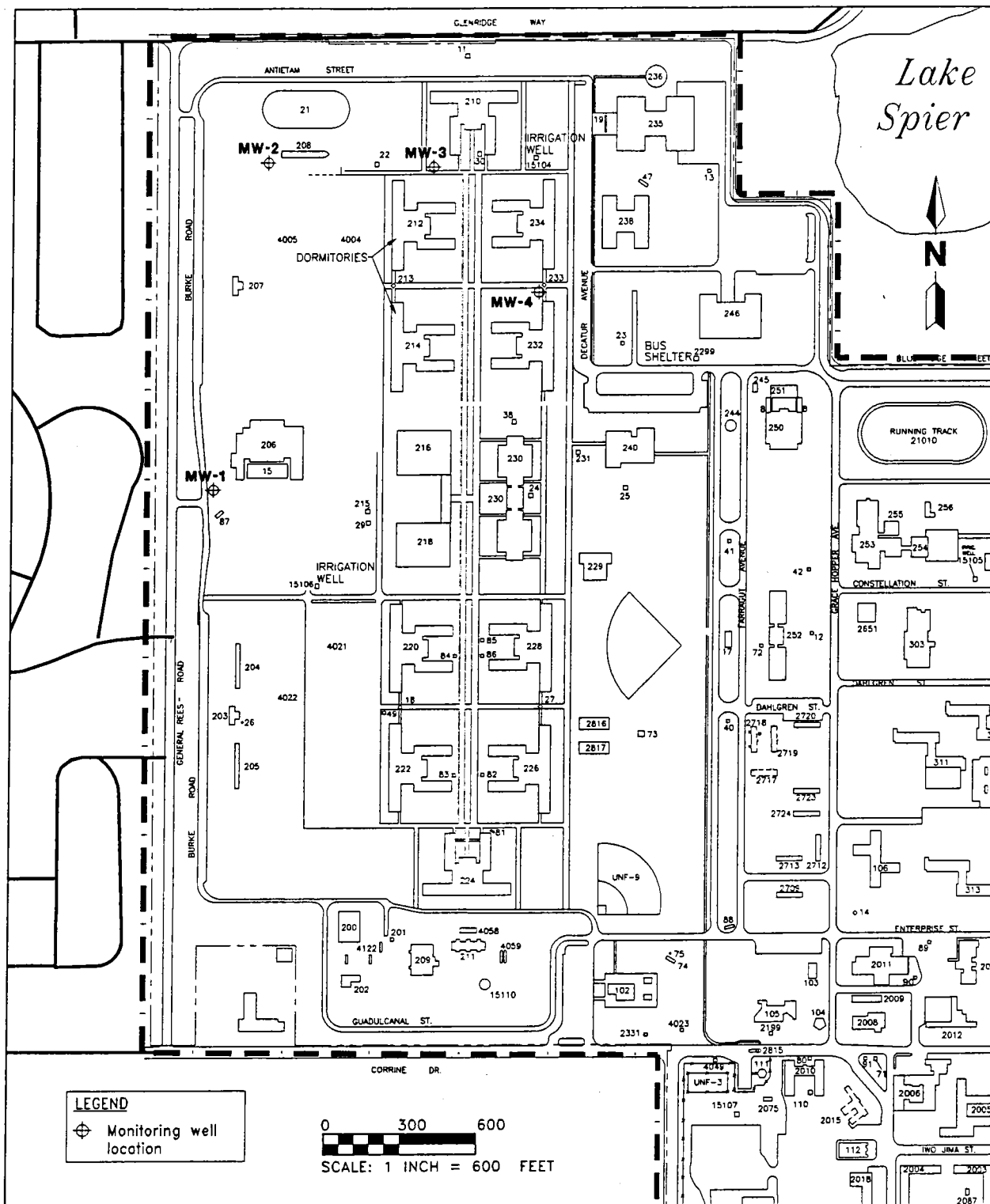


FIGURE 1-7
MONITORING WELL LOCATIONS
VERIFICATION STUDY
NORTH GRINDER AREA



REMEDIAL INVESTIGATION
OPERABLE UNIT 1
NORTH GRINDER LANDFILL

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Table 1-1
Summary of Results of Groundwater Analyses

Remedial Investigation Report, Operable Unit 1
 North Grinder Landfill
 Naval Training Center
 Orlando, Florida

Compound	Location	Concentration	Federal MCL	State MCL
Iron	MW-1	1.5 ppm	N/A	0.3 ppm ¹
Arsenic	MW-3	68 ppb	50 ppb	50 ppb
Gross alpha	MW-1 thru MW-4	20 to 41 pCi/ℓ	15 pCi/ℓ	15 pCi/ℓ
Gross beta	MW-1 thru MW-4	28 to 38 pCi/ℓ	50 pCi/ℓ ²	50 pCi/ℓ ²
Methylene chloride (dichloromethane)	MW-4	15 ppb	5 ppb	5 ppb

¹ Secondary standard.

² Gross beta screening level is being referenced because specific nuclides must be known in order to convert to dose (whole body or organ) before a comparison to the 4 millirem per year Federal and State MCL can be made.

Notes:

RI = Remedial Investigation.

ppm = parts per million.

MCL = maximum contaminant level.

ppb = parts per billion.

N/A = not applicable.

pCi/ℓ = picocuries per liter.

2.0 REMEDIAL INVESTIGATION ACTIVITIES AND RATIONALE

The following subsections provide a description of the field activities which have been completed for site characterization at OU 1. The investigation which took place was focused, consistent with the presumptive remedy of containment. The Conceptual Site Model developed during the workplan (ABB-ES, 1995d) has made reasonable assumptions regarding various contamination pathways and receptors, but has allowed for potential deviations from those initial assumptions to permit flexibility during the implementation of the field investigation. All of the activities were performed in accordance with the guidelines set forth in the POP (ABB-ES, 1994b). All well installation, development, and sampling activities were performed in accordance with Southern Division, Naval Facility Engineering Command (SOUTHNAVFACENGCOM) guidelines for groundwater monitoring well installation (ABB-ES, 1994b) and as specified in the USEPA Region IV ECBSOPQAM (USEPA, 1991c).

2.1 LEVEL II DATA QUALITY OBJECTIVE (DQO) INVESTIGATIVE METHODS. (This section is not included as it is considered nonessential for this submittal).

2.1.1 Aerial Photography Evaluation Historical aerial photographs, provided by the Navy at the Public Works Office, were evaluated during the planning phases of this RI. The most useful photographs were from the early 1960's (the Grinder Landfill was in operation from its beginnings sometime between 1939 and 1947 up until the Air Force transferred the property to the Navy in 1968). They indicate that the landfill was probably operated as several long northeast-southwest trenches (Figure 1-4). While burning has not been documented for the North Grinder Landfill, it may have taken place.

Figure 1-4 shows the North and South Grinder Parade Areas during what is believed to be the height of landfiling activity in the North Grinder Area. The bare area in the South Grinder Parade Area prompted an evaluation of whether or not landfiling activity might have taken place (Section 2.1.2, below).

2.1.2 Geophysical Surveys A geophysical survey was conducted at OU 1 between March 7 and April 6, 1995. The objectives for the survey were to determine the

"footprint" of the North Grinder Landfill; locate "hot spots" in the North Grinder Landfill that might indicate areas within the landfill that might warrant source removal; and characterize the landfill cover thickness and continuity, to evaluate potential exposure. Geophysical techniques employed during these surveys included magnetometry, terrain conductivity, time domain metal detector, and ground penetrating radar (Figure 2-1). A global positioning system survey was also completed to locate key features more accurately.

The reconnaissance magnetometer survey in the South Grinder Parade Area indicated that the South Grinder Area had likely not been used for landfilling activities. This permitted a focusing of the remainder of the investigation to the North Grinder Area where geophysics was successful in determining the footprint of the Landfill (Figure 2-2) and in mapping areas that may indicate concentrations of buried metallic wastes. A hand augering program conducted in conjunction with the passive soil gas program (Subsection 2.1.4) was useful in determining the thickness of cover materials over the landfill.

2.1.3 Direct Push Technology (DPT) Surveys Direct Push Technology (DPT) methods were employed during initial groundwater screening activities after the boundaries of the North Grinder landfill had been defined by the geophysical investigation (Figure 2-3). The objectives for the DPT investigations were to define any contaminant plume(s) that may be present in the surficial aquifer and thus assist in optimally locating permanent well installations. The survey involved a TerraProbeSM investigation followed by an electric cone penetrometer test (CPT) program. The TerraProbeSM was used to collect groundwater samples from the shallow and intermediate depth ranges of the surficial aquifer, while the CPT system was used to collect groundwater samples from the deeper portions of the surficial aquifer and to obtain stratigraphic data. The TerraProbeSM was also used to install permanent soil vapor implants around the perimeter of the Landfill to allow monitoring of potential lateral migration of landfill gases (Figure 2-4). All groundwater and soil gas samples were analyzed on a field gas chromatograph to provide the field team with near real time data by which they could optimize locations for subsequent explorations. ABB-ES verified during initial site activities that groundwater flow is northerly with a probable northeast flow component.

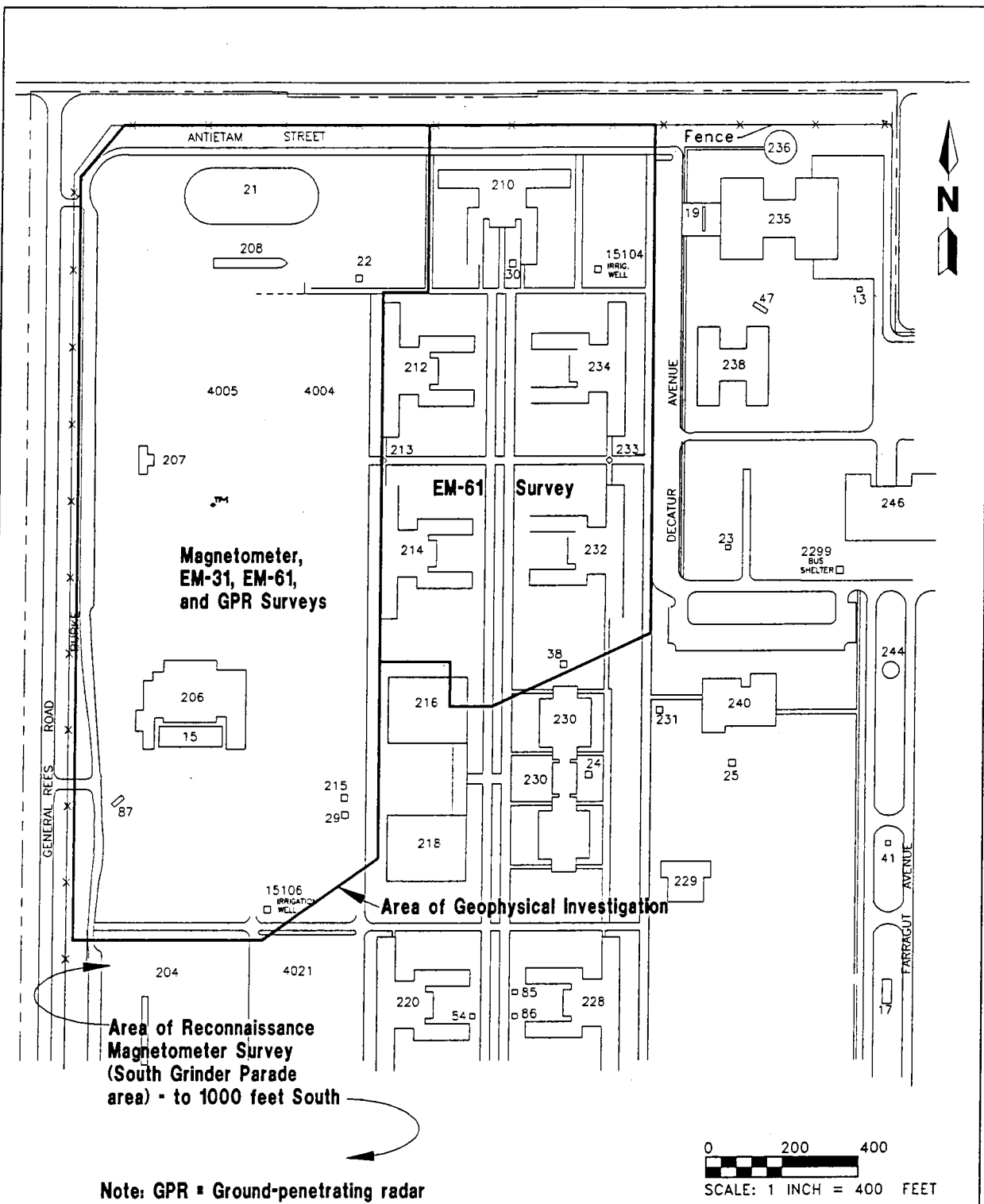


FIGURE 2-1
AREA OF GEOPHYSICAL INVESTIGATIONS



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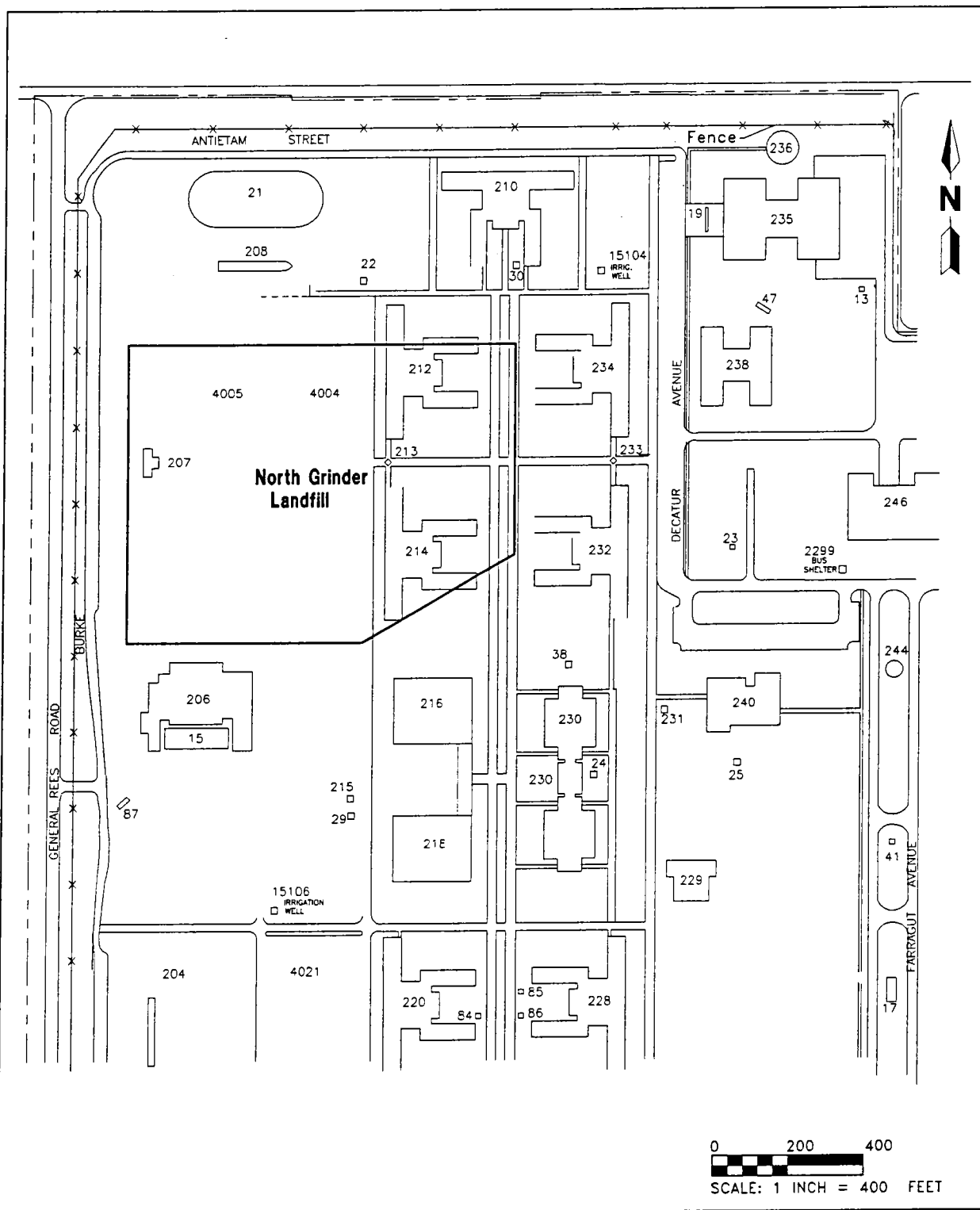
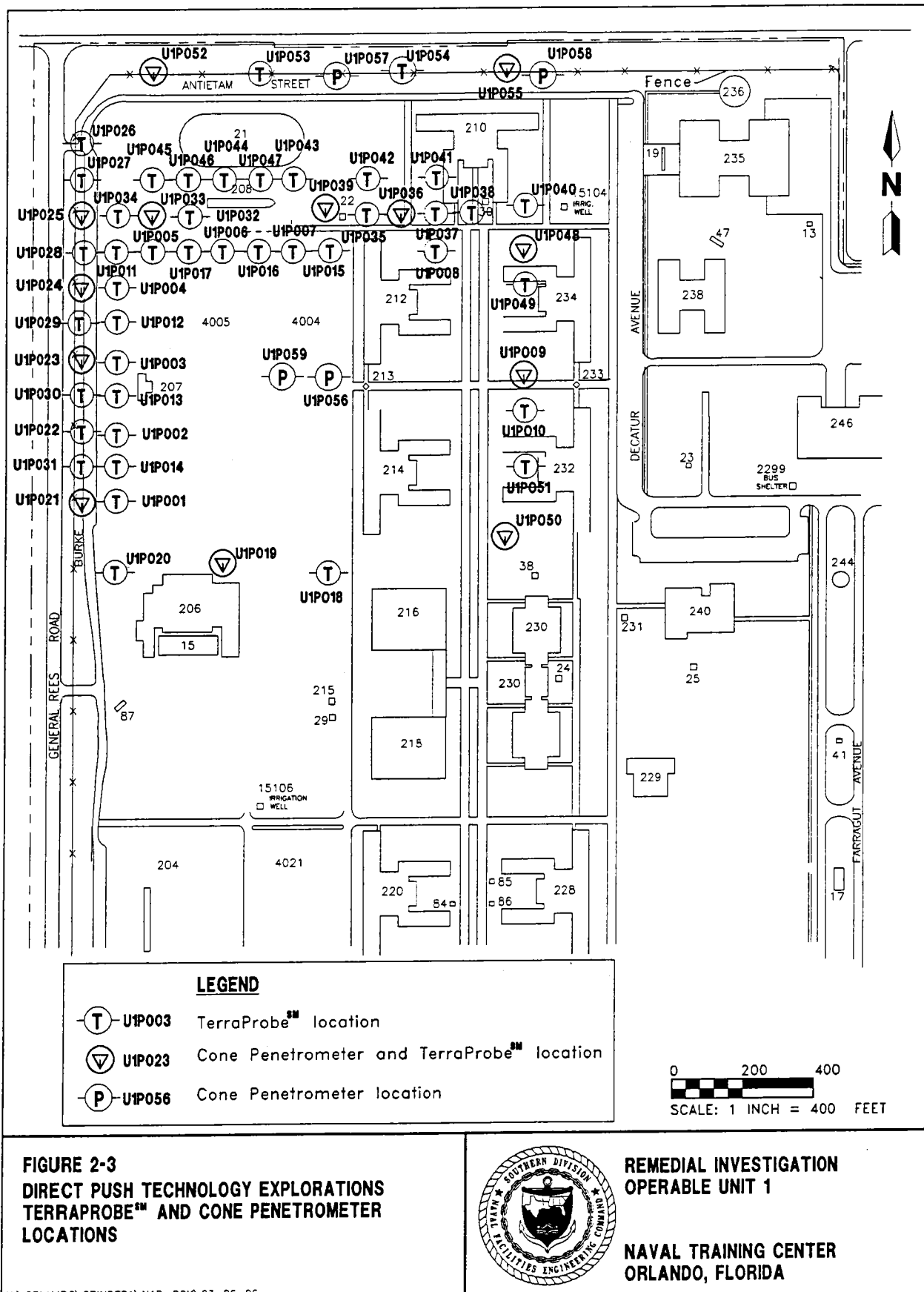


FIGURE 2-2
INTERPRETED LOCATION OF LANDFILL
FROM GEOPHYSICAL DATA



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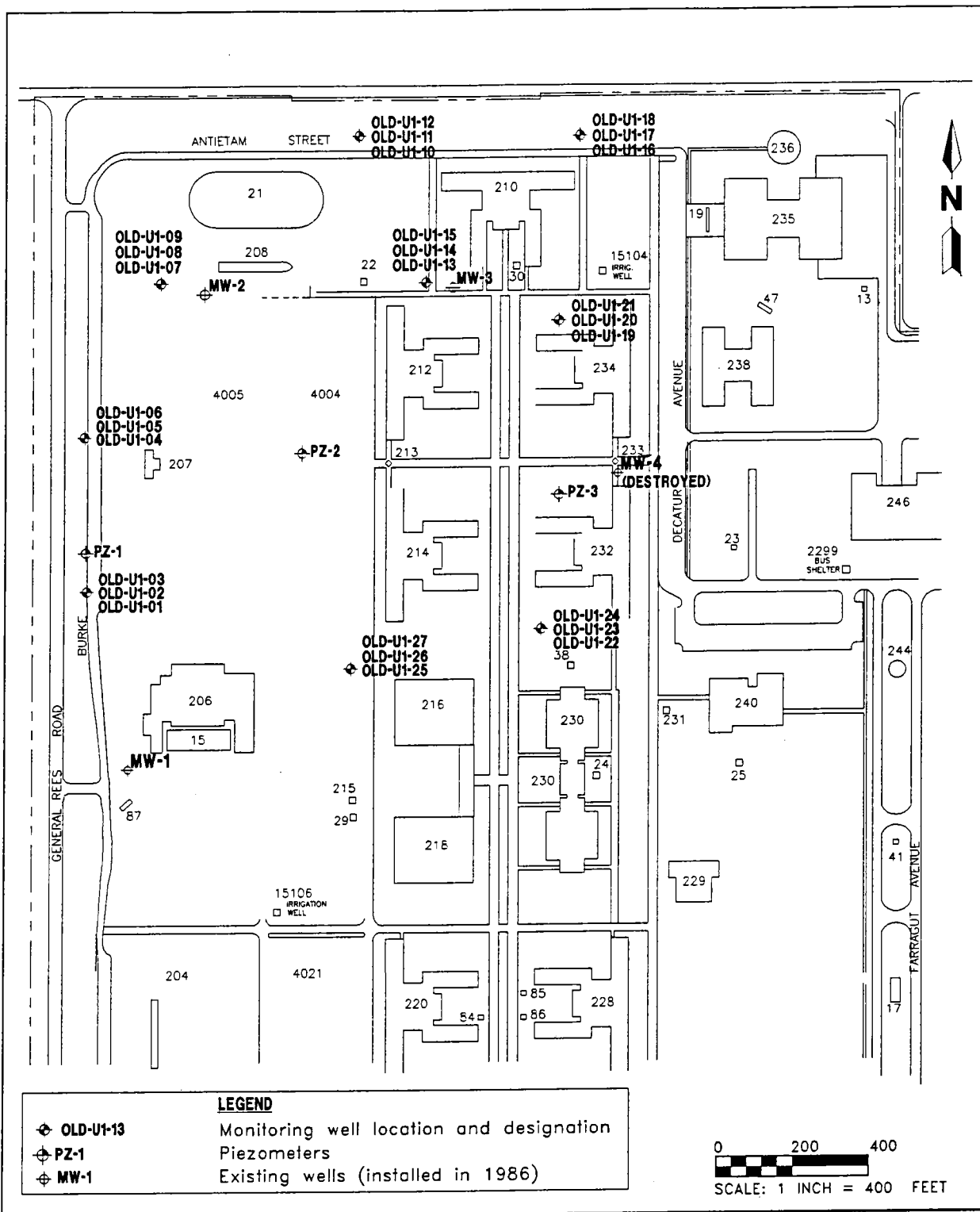
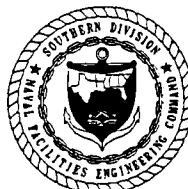


FIGURE 2-5
MONITORING WELL AND PIEZOMETER
LOCATIONS



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2.1.3.1 TerraProbeSM Surveys The TerraProbeSM rig was used to collect groundwater screening samples from 55 locations outside of the perimeter of the landfill to screen for the presence of contamination in the shallow and intermediate depths of the surficial aquifer (Figure 2-3). The majority of the samples were collected from the 14 to 19 foot interval. A second depth was sampled at 46 of the 55 sampling locations.

The groundwater samples were analyzed on a field gas chromatograph (GC), which provided concentrations of benzene, toluene, ethylbenzene, and xylenes (BTEX), trichloroethene (TCE), and PCE. Ten samples were submitted to an offsite laboratory for volatile organics analysis using CLP methodology.

The results of the TerraProbeSM groundwater screening effort revealed that very low levels of contaminants were present along the northwest and northern portions of the landfill, and those zones where contaminants were detected formed the basis for monitoring well location selection. Additional details on the groundwater screening results from the DPT surveys are included in Appendix B.

2.1.3.2 CPT Surveys Upon completion of the TerraProbeSM groundwater sampling event, fifteen locations were chosen for further investigation by CPT soundings and deep groundwater sampling (Figure 2-3). The CPT soundings were used to provide the stratigraphic data for the surficial aquifer at the site, and the groundwater screening results were used to provide general plume delineation. The data were used to develop an installation and construction plan for the network of monitoring wells.

CPT Soundings. The CPT sounding provides a continuous logging of soil lithologic properties for the entire length of the boring. The Cone Penetrometer measures tip resistance and sleeve friction as the cone is advanced through the soil. The soil classification is based on the values of these properties and the ratio of sleeve friction to tip stress. The results of the CPT survey, which includes stratigraphic logs resulting from the 15 cone tests (two cone tests encountered refusal at a shallow depth) are presented as Appendix C.

Groundwater Screening. Thirty-two groundwater samples were collected at thirteen CPT sounding locations. Depending on lithology, two or three depths were sampled

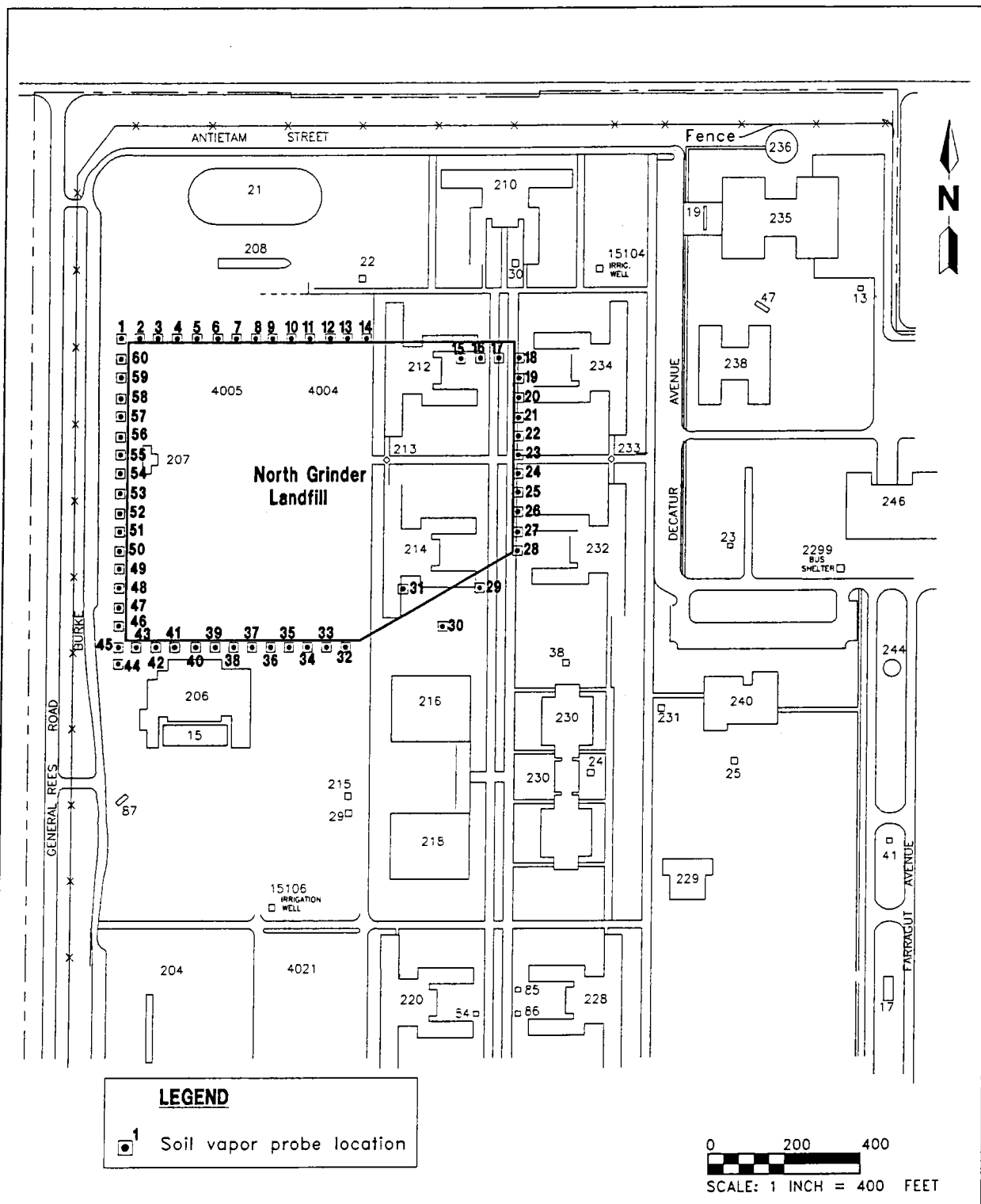
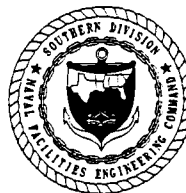


FIGURE 2-4
SOIL VAPOR PROBE LOCATIONS



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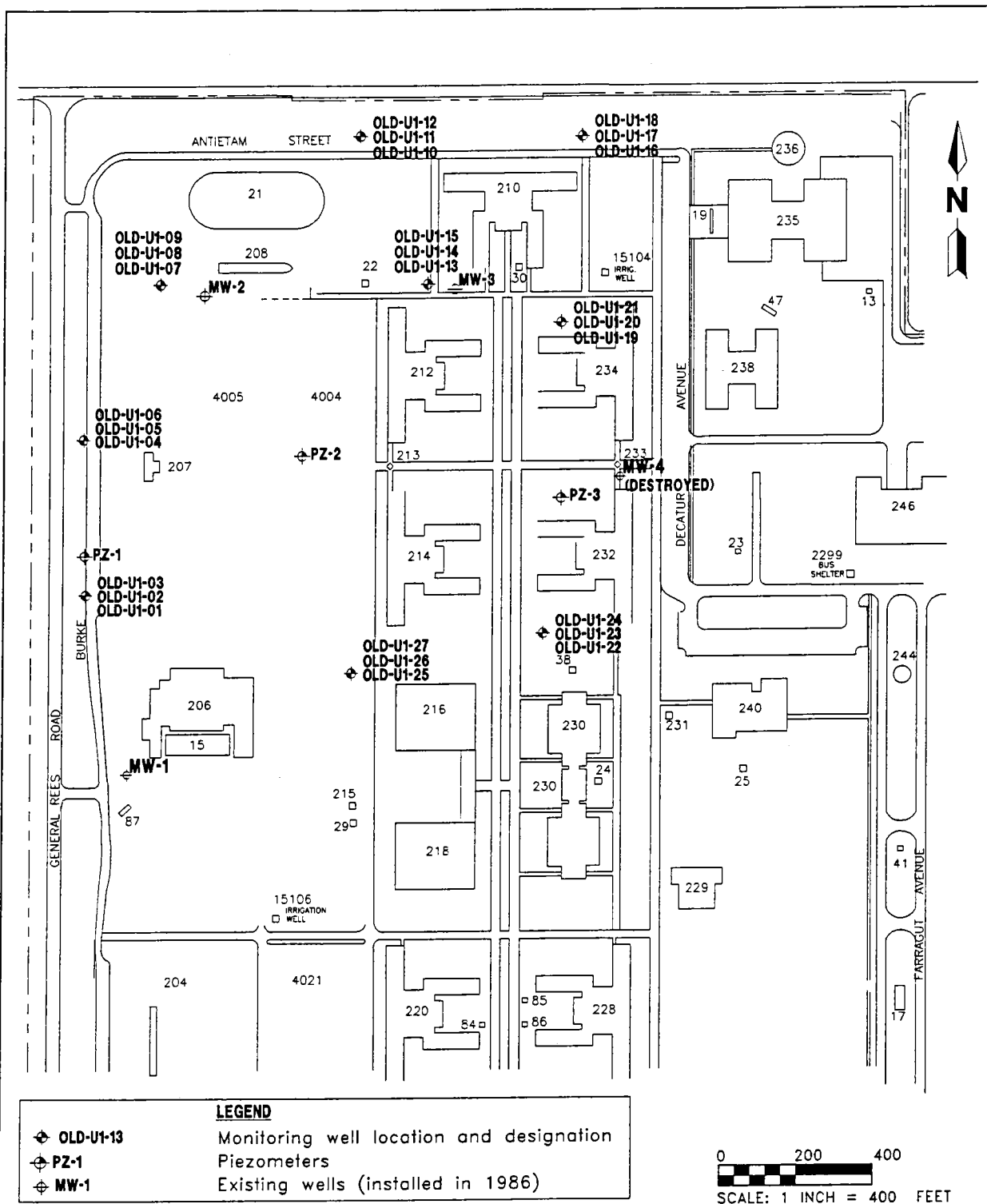
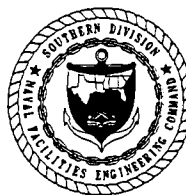


FIGURE 2-5
MONITORING WELL AND PIEZOMETER
LOCATIONS



REMEDIAL INVESTIGATION
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per location. Samples were collected near the water table, above any intermediate stratigraphic units that might have inhibited vertical migration of contaminants, and above the clay unit interpreted as the top of the Hawthorn Group.

All of the groundwater samples collected during the DPT survey were analyzed onsite by a portable GC to determine the concentration of any petroleum-related volatile organic compounds as well as selected volatile chlorinated solvents.

2.1.4 Passive Soil Gas Survey A passive soil gas survey was completed at OU 1 for the purpose of characterizing chemicals of potential concern (CPCs) present in the soil cover so that a proper soil gas collection system can be designed (if needed) and to allow for proper cap design; characterizing volatile and semivolatile constituents that have migrated to the landfill soil cover to locate potential "hot spots", which may need to be evaluated with regards to source removals to support remedial alternatives; and evaluating the presence of methane, which may still be problematic despite the age of the landfill.

The soil gas collectors consisted of a glass sampling vial coated with an adsorbent fused to the inside bottom of the vial. The collectors were deployed at a depth of two to three feet below land surface (bls) at their respective sampling locations for a duration of three to five days. They were then retrieved and submitted for analysis.

A total of 303 passive soil gas collectors were installed (Figure 2-6) over the landfill area. Samples were analyzed according to modified EPA Methods 8010 and 8020. Modified EPA Method 8010 analysis was conducted with a gas chromatograph equipped with an electron capture detector (ECD) using direct injection and the analytes standardized for analysis were: 1,1-dichloroethene (1,1-DCE), methylene chloride (CH₂CL₂), trans-1,2-dichloroethene (t12DCE), 1,1-dichloroethane (1,1-DCA), cis-1,2-dichloroethene (c12DCE), chloroform (CHCL₃), 1,1,1-trichloroethane (1,1,1-TCA), carbon tetrachloride (CCL₄), trichloroethene (TCE), 1,1,2-trichloroethane (1,1,2-TCA), and perchloroethylene (PCE).

Modified EPA Method 8020 analysis was conducted with a gas chromatograph with a flame ionization detector using direct injection. The analytes standardized for

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analysis were: benzene, toluene, ethylbenzene, meta- and para- xylene, and ortho-xylene.

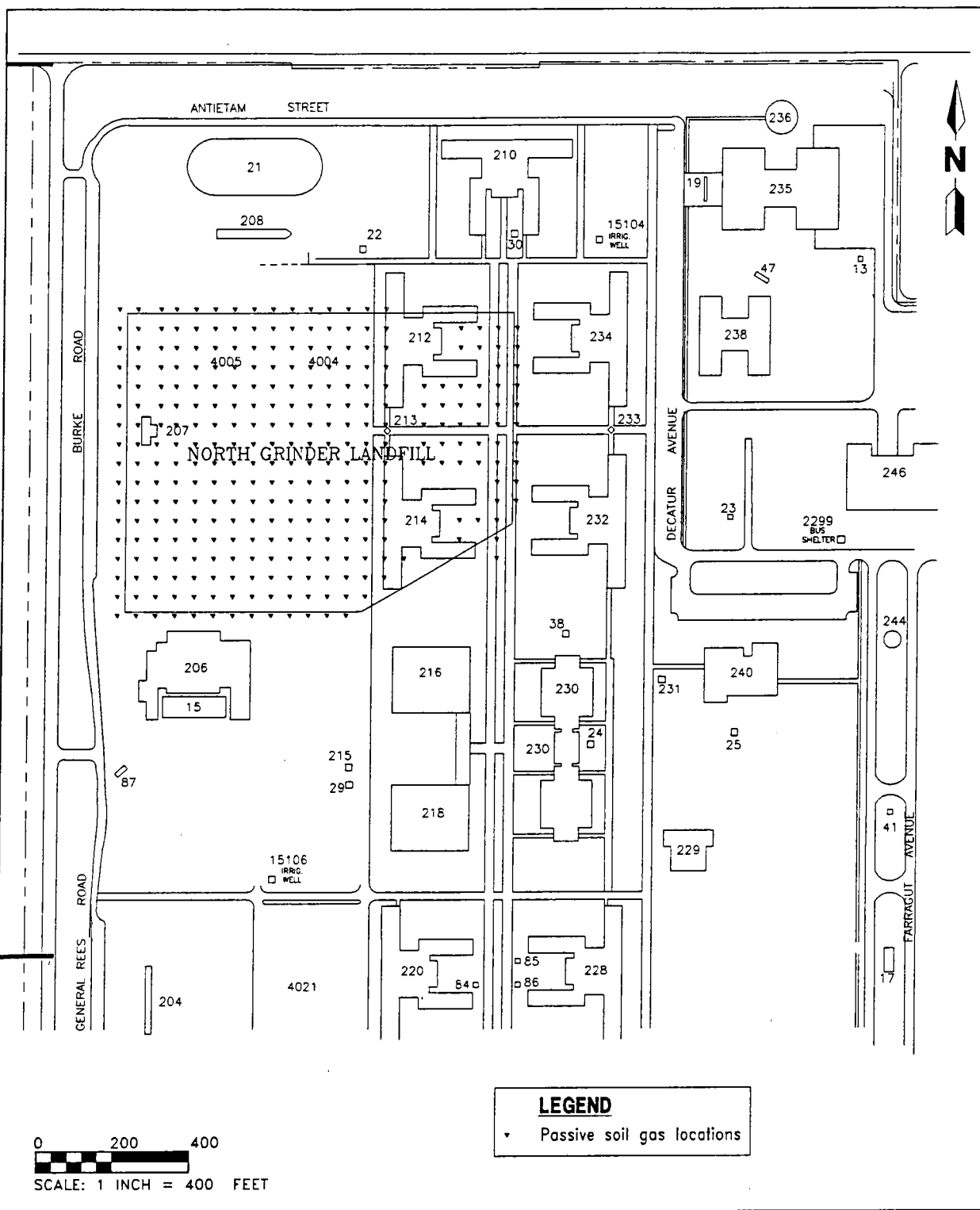
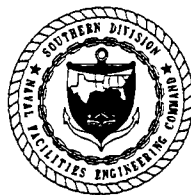


FIGURE 2-6
PASSIVE SOIL GAS LOCATIONS
OPERABLE UNIT 1,
NORTH GRINDER LANDFILL



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OPERABLE UNIT 1
NORTH GRINDER LANDFILL
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A hand augering program was completed in conjunction with the installation of 303 passive soil gas collectors to depths ranging from 22 to 36 inches bls. The soil cover is a minimum of 22 inches thick except in 2 locations where refuse was encountered at a depth of 18 inches bls.

The results of the passive soil gas survey along with a summary of the hand augering program completed during passive soil gas collector installation is presented in Appendix D-1.

2.1.5 Active Soil Gas Survey An active soil gas survey was conducted at OU 1 to evaluate the presence and potential lateral migration of methane generated by landfilled materials, an important consideration of source containment under the presumptive remedy. Sixty active soil gas sampling implants were installed around the perimeter of the landfill (Figure 2-4). The implants were spaced at approximately 50-foot intervals, except in the northeast and southeast corners, where buildings prevented implant placement.

The results of the GC analyses and methane screening are presented in Appendix D-2.

2.1.6 Soil Borings The objective for installing soil borings was to verify the lithologic data obtained by DPT methods and to characterize the site geologically. Based on DPT results (55 TerraProbeSM sampling points with 117 groundwater screening samples, and 15 CPT soundings with 35 groundwater samples from 13 locations), nine monitoring well cluster locations were selected which would best characterize the local geology and hydrology at OU 1 (Figure 2-5). Each cluster was comprised of three monitoring wells screened at the water table, at an intermediate depth within the surficial aquifer, and at the top of the Hawthorn Group at the base of the surficial aquifer.

The deep well at each cluster location was sampled continuously to the uppermost clay lens/layer within the Hawthorn Group providing lithologic data which would be correlated with the DPT results to construct the stratigraphic framework

beneath the study area. Soil samples were collected in accordance with Subsection 4.5.1 of the POP (ABB-ES, 1994b).

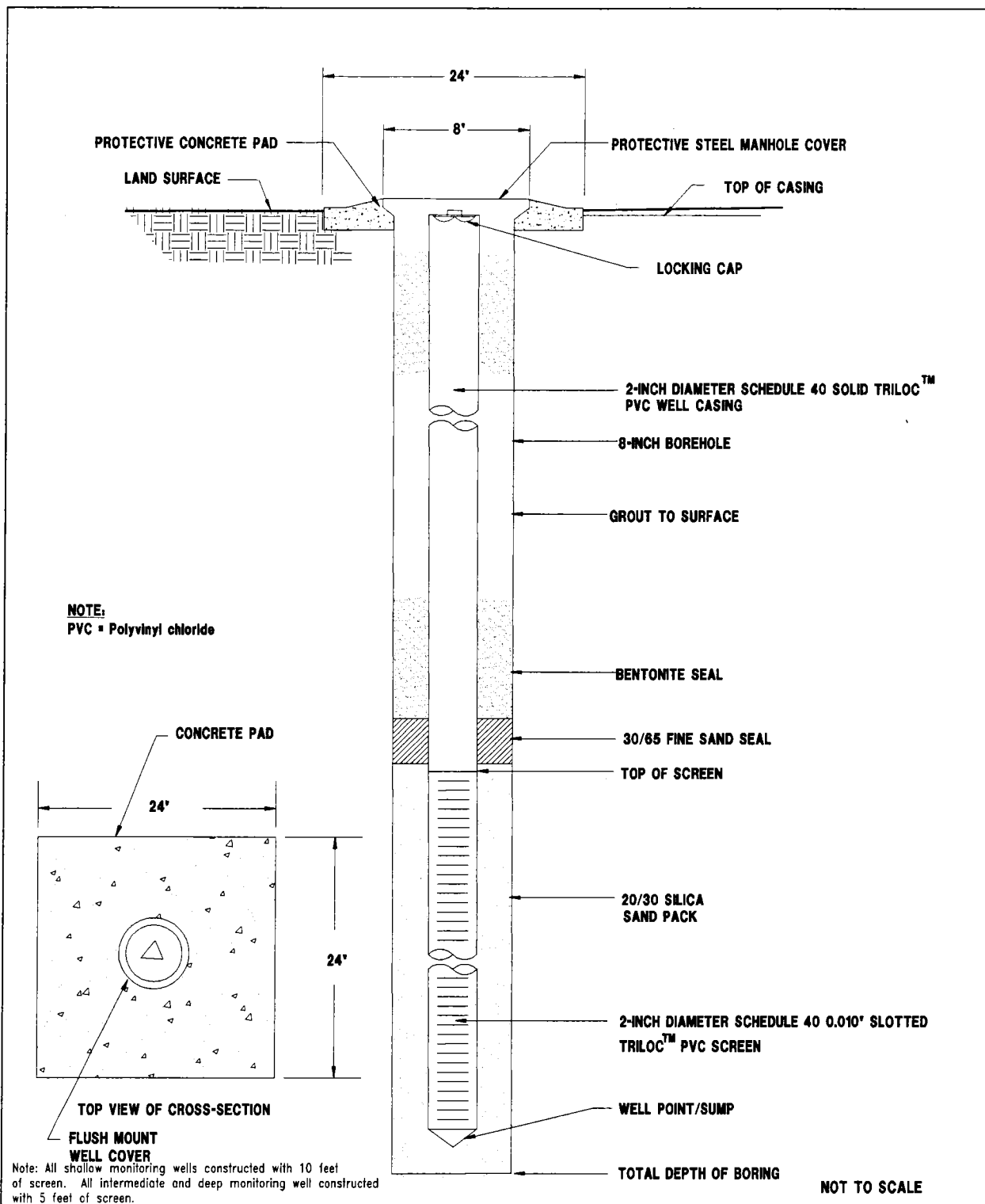
Soil Boring Logs are presented in Appendix E.

2.1.7 Monitoring Well Installation Three monitoring wells were installed at each of the nine clusters for a total of twenty seven permanent wells to characterize the groundwater quality and hydraulic characteristics of the surficial aquifer (Figure 2-5). Monitoring well clusters were installed because of the differing migration properties of potential contaminants present. Cluster locations were selected which would best characterize the local geology and hydrology at OU 1. Each cluster was comprised of three monitoring wells screened at the water table (12.5 to 22.5 feet bls), at an intermediate depth within the surficial aquifer (27.5 to 49.5 feet bls), and at the top of the Hawthorn Group at the base of the surficial aquifer (47.5 to 69.5 feet bls).

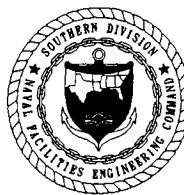
Shallow wells were constructed to bracket the water table and thus capture light nonaqueous-phase liquid (LNAPL). The placement of the intermediate wells was controlled by lithology and was intended to screen the interval above potential vertical migration barriers which would act as contaminant accumulation points within the surficial aquifer. If appropriate lithologies were not encountered, then intermediate wells were screened approximately halfway between the water table and the base of the surficial aquifer. Deep wells were screened above the uppermost clay layer within the Hawthorn Group.

Monitoring Well Construction Diagrams and monitoring well development logs are provided in Appendices F-1 and F-2.

2.1.8 Aquifer Characterization In-situ hydraulic conductivity tests were performed on the 27 monitoring wells installed during this investigation. The results are presented in Appendix H and discussed in Chapter 3.



**FIGURE 2-7
TYPICAL MONITORING
WELL CONSTRUCTION DETAIL**



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Table 2-1
Monitoring Well Construction Details

Remedial Investigation Report, Operable Unit 1
North Grinder Landfill
Naval Training Center
Orlando, Florida

Well ID	Date Installed	Borehole Depth (feet bls)	Well Depth (feet bls)	Screen Interval	Filter Pack Interval	Seal Interval	Grout Interval
OLD-U1-01	6/19/95	13	12.5	2.5-12.5	1.5-13	1-1.5	0-1
OLD-U1-02	6/19/95	28	27.5	22.5-27.5	20.5-28	18.5-20.5	0-20.5
OLD-U1-03	6/19/95	58	57.5	52.5-57.5	50.5-58	48.5-50.5	0-50.5
OLD-U1-04	6/21/95	21	20.5	10.5-20.5	8.5-21	6.5-8.5	0-6.5
OLD-U1-05	6/21/95	37	36.5	31.5-36.5	29.5-37	27.5-29.5	0-27.5
OLD-U1-06	6/20/95	58	57.5	52.5-57.5	50.5-58	48.5-50.5	0-48.5
OLD-U1-07	6/22/95	22	21.5	11.5-21.5	10.5-13	8-10.5	0-8
OLD-U1-08	6/22/95	41	40.5	35.5-40.5	33.5-41	31.5-33.5	0-31.5
OLD-U1-09	6/22/95	57	56.5	51.5-56.5	49.5-57	47.5-49.5	0-47.5
OLD-U1-10	7/7/95	23	22.5	12.5-22.5	11-23	8-11	0-8
OLD-U1-11	7/7/95	40	39.5	34.5-39.5	33-40	31-33	0-31
OLD-U1-12	7/6/95	65	64.5	59.5-64.5	58-65	56-58	0-56
OLD-U1-13	6/26/95	23	22.5	12.5-22.5	11-23	9-11	0-9
OLD-U1-14	6/26/95	40	39.5	34.5-39.5	33-40	31-33	0-31
OLD-U1-15	6/26/95	54.5	54	49-54	47-54.5	45-47	0-45
OLD-U1-16	7/5/95	20	19.5	9.5-19.5	8-19.5	6-8	0-6
OLD-U1-17	7/5/95	35	34.5	24.5-34.5	28-35	26-28	0-26
OLD-U1-18	6/30/95	48	47.5	37.5-47.5	41-48	39-41	0-39
OLD-U1-19	6/29/95	23	22.5	12.5-22.5	16-23	14-16	0-14
OLD-U1-20	6/29/95	35	34.5	29.5-34.5	28-35	26-28	0-26
See notes at end of table							

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Table 2-1 (Continued)
Monitoring Well Construction Details

Remedial Investigation Report, Operable Unit 1
North Grinder Landfill
Naval Training Center
Orlando, Florida

Well ID	Date Installed	Borehole Depth (feet bls)	Well Depth (feet bls)	Screen Interval	Filter Pack Interval	Seal Interval	Grout Interval
OLD-U1-21	6/30/95	41	50.5	45.5-50.5	44-51	42-44	0-42
OLD-U1-22	6/15/95	20	19.5	9.5-19.5	8-20	6-8	0-6
OLD-U1-23	6/15/95	40	35.5	35.5-39.5	33.5-40	31.4-33.5	0-33.5
OLD-U1-24	6/16/95	70	69.5	64.5-69.5	62.5-70	60.5-62.5	0-60.5
OLD-U1-25	6/13/95	20	19.5	9.5-19.5	8-20	6-8	0-6
OLD-U1-26	6/13/95	50	49.5	44.5-49.5	42.5-50	40.5-42.5	0-40.5
OLD-U1-27	6/12/95	63	62.5	57.5-62.5	56.5-63	54.5-56.5	0-54.5
<p>Note: All wells constructed with 2-inch Schedule 40 PVC casing and screen. All well screens are equipped with 0.01 inch slots. All soil borings were advanced with 6-1/4-inch I.D. augers (10-inch nominal O.D.).</p> <p>Source: ABB, 1995.</p>							

2.1.9 Sample Point Elevation Survey Prior to the initiation of field work, a reference grid with arbitrary northing and easting coordinates was established over the study area. The northing and easting (North American Datum [NAD] 83 datum and State Plane Florida East Zone grid coordinate system) of each of these points was surveyed by ABB-ES personnel using a Global Positioning System (GPS) satellite receiver connected to a real time differential correction receiver (Appendix A).

Each of the 27 permanent monitoring well locations were surveyed by registered professional surveyors. The surveyors established the elevation (referenced to mean sea level), and northing and easting coordinates (NAD 83, Florida East Zone) of the top of the casing of each well. (This Subsection has been shortened in the interest of presenting only essential data for this submittal).

2.2 LEVEL IV DQO INVESTIGATIVE METHODS. (This Section has been omitted in the interest of presenting only essential data for this submittal).

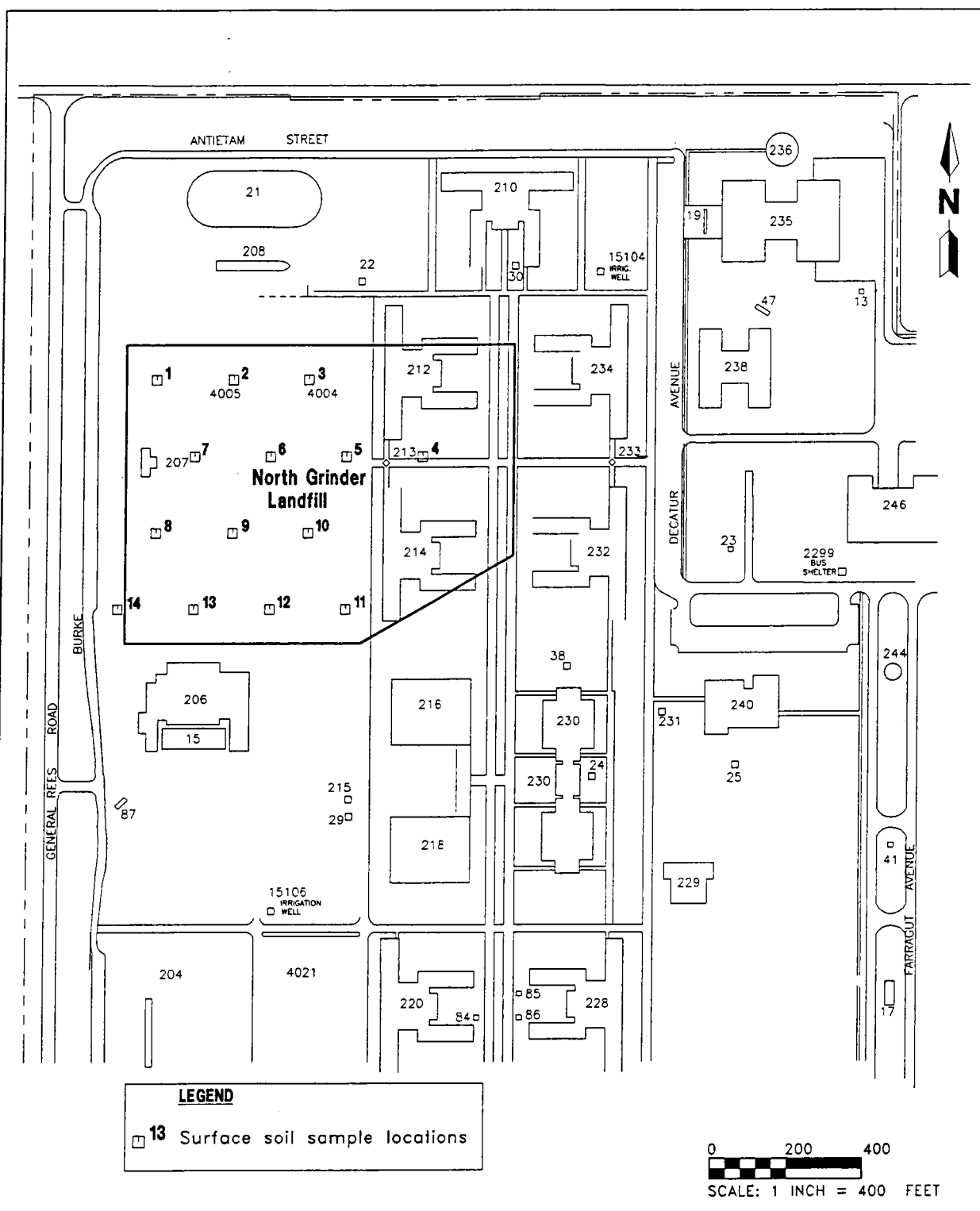


FIGURE 2-8
SURFACE SOIL SAMPLE LOCATIONS



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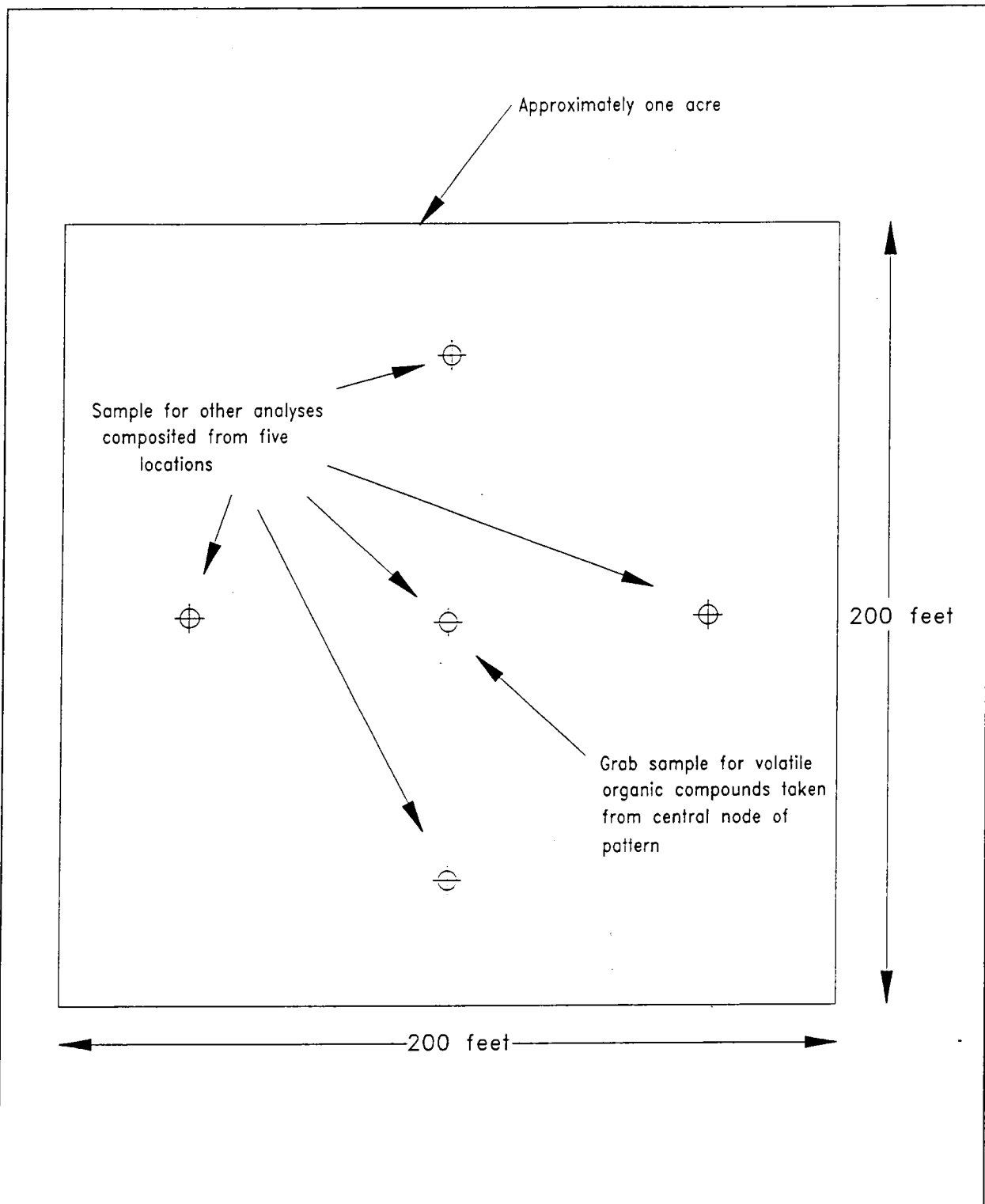


FIGURE 2-9
COMPOSITE PATTERN FOR SURFACE SOIL
SAMPLING



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3.0 REGIONAL AND SITE-SPECIFIC SETTING CONDITIONS

The following section describes the regional and site-specific physical characteristics of the area, including the physiography, climate, surface water hydrology, surface soil, geology, hydrogeology, demography, and local ecology. The presented information was gathered from surface and subsurface exploration, field observations, sample collection, and review of available published and unpublished data.

3.1 PHYSIOGRAPHY. (This section not included as it is considered nonessential for this submittal).

3.2 CLIMATE. (This section not included as it is considered nonessential for this submittal).

3.3 SURFACE WATER HYDROLOGY. (This section not included as it is considered nonessential for this submittal).

3.4 SURFACE SOIL. (This section not included as it is considered nonessential for this submittal).

3.5 GEOLOGY.

3.5.1 Regional The upper 2,000 feet or so of the subsurface in central Florida is divided into three separate lithologic units:

- The surficial deposits are a thin (generally less than 100 feet) sequence of undifferentiated terrace deposits of Recent and Pleistocene age.

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- The underlying Hawthorn Group is a thin (generally less than 100 feet) sequence of mixed unconsolidated clastic material and carbonates of Miocene age.
- The Hawthorn overlies a thick (more than 1,200 feet) sequence of Eocene-age marine carbonates (Figures 3-4 and 3-5). The carbonate sequence is divided into three units: the Ocala Group, the Avon Park Limestone, and the Lake City Limestone (Figure 3-6). The major regional characteristics of these units is addressed in detail below.

(The remainder of this section not included as it is considered nonessential for this submittal).

3.5.2 Local The subsurface exploration activities performed during the field investigation were limited to the undifferentiated surface deposits and the upper 20 to 30 feet of the Hawthorn Group. Data collected from selected piezocone soundings and from standard penetration test (SPT) samples collected at each deep soil boring were used to construct east to west (A-A') and north to south (B-B') geologic cross-sections (Figure 3-7). The cross-sections are presented in Figures 3-8 and 3-9, respectively.

The undifferentiated surficial deposits can be generally divided into three separate units based on differing textural characteristics. The first unit is a light gray to brown silty fine sand. This unit was encountered throughout the upper 15 to 20 feet as well as the lower 10 to 20 feet of the surficial deposits. In general, this unit becomes finer grained on the east side of the study area and in the lower portion of the surficial section. The second unit is a light gray to dark brown silty fine sand with intermingled layers of sandy silt. At several locations, sections up to two feet thick within this unit were partially cemented. This unit retains a fairly constant thickness of 15 to 20 feet across the area, but is thinner on the east and north portions of the area. The third unit is a yellow to tan silty fine sand with intermingled layers of gray silty clay. This unit extends from the southwest corner to the central portion of the study area. It reaches a maximum thickness of approximately 10 feet.

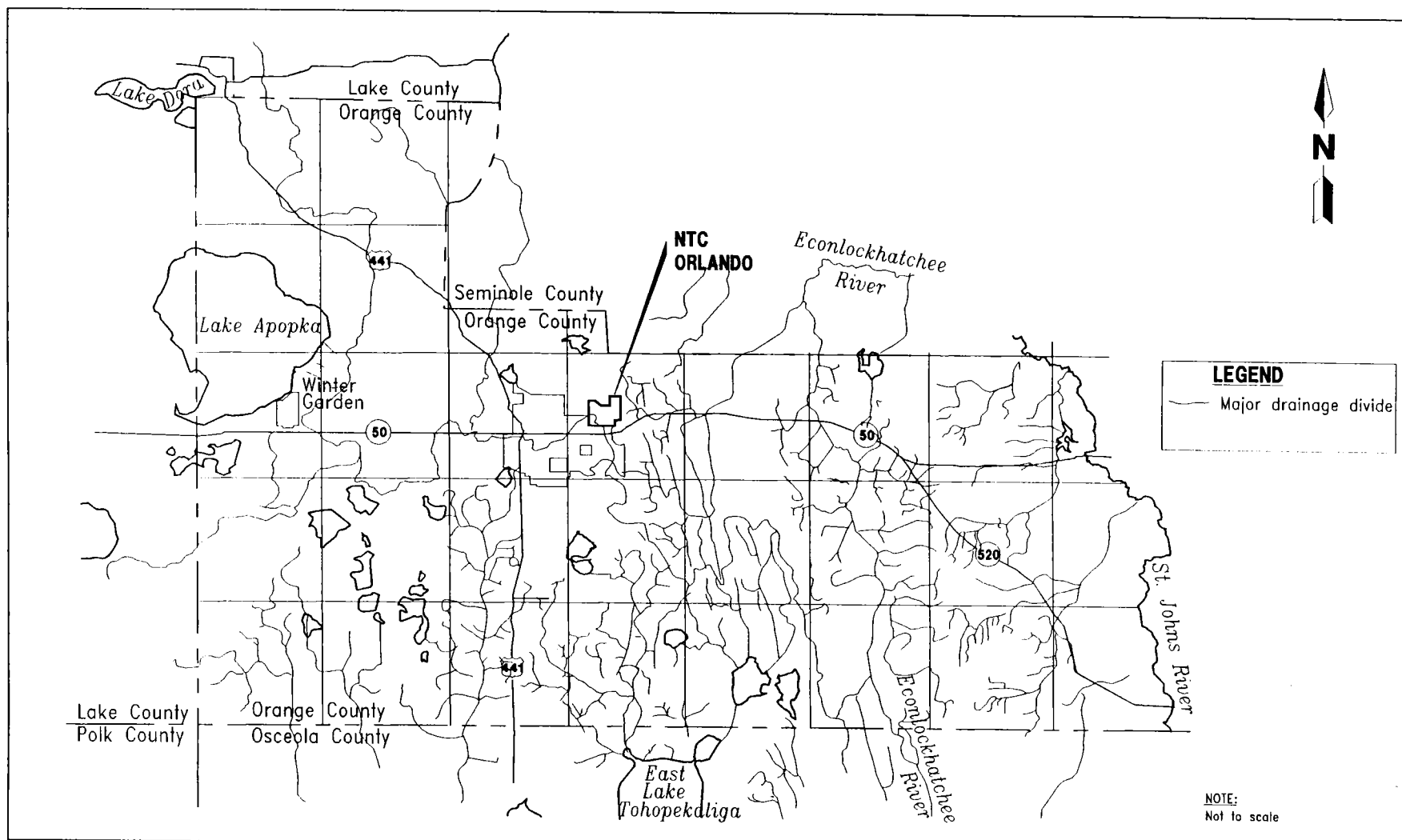


FIGURE 3-1
TOPOGRAPHIC MAP



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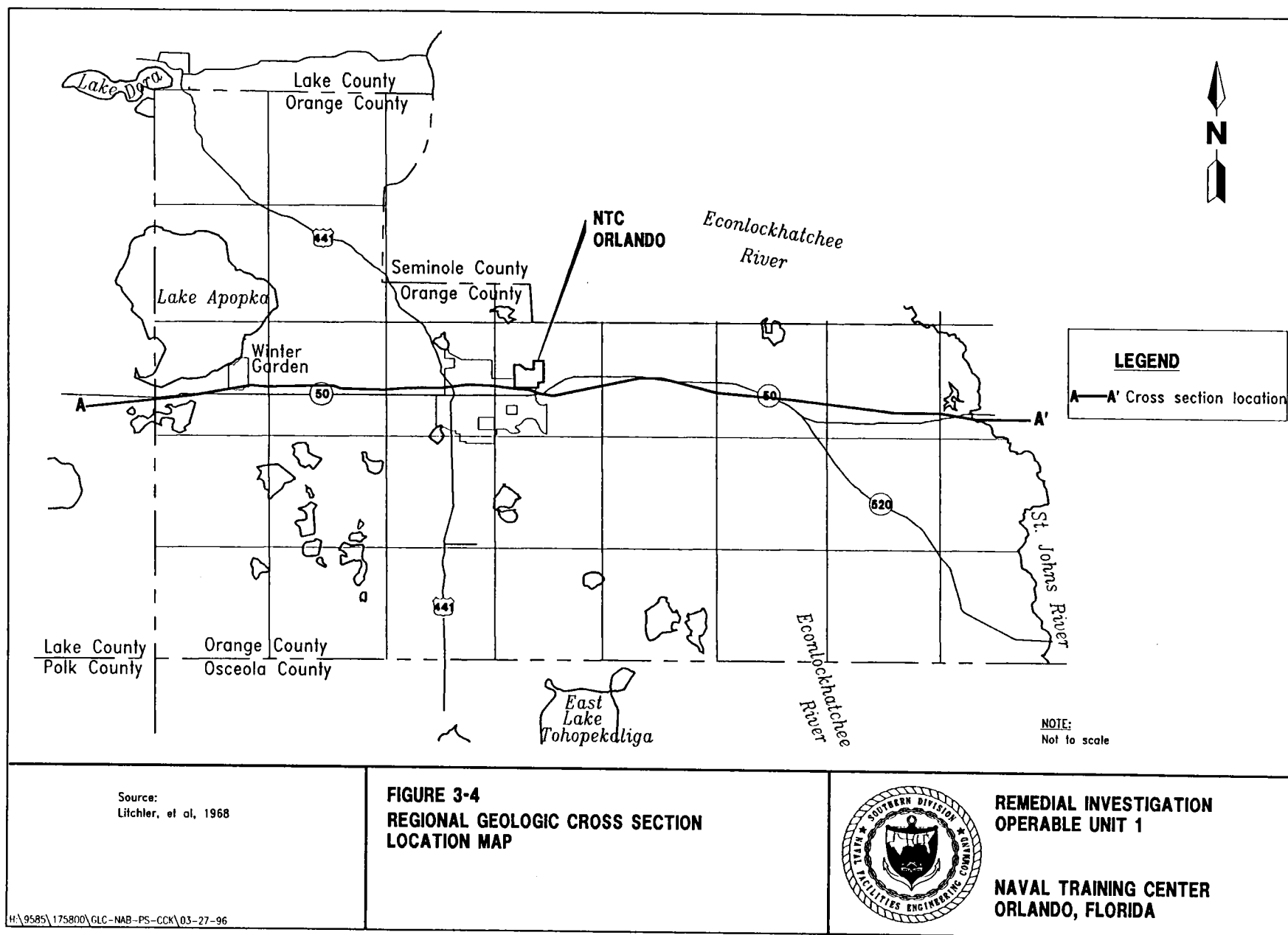
Source:
United States Geological Survey, 1968

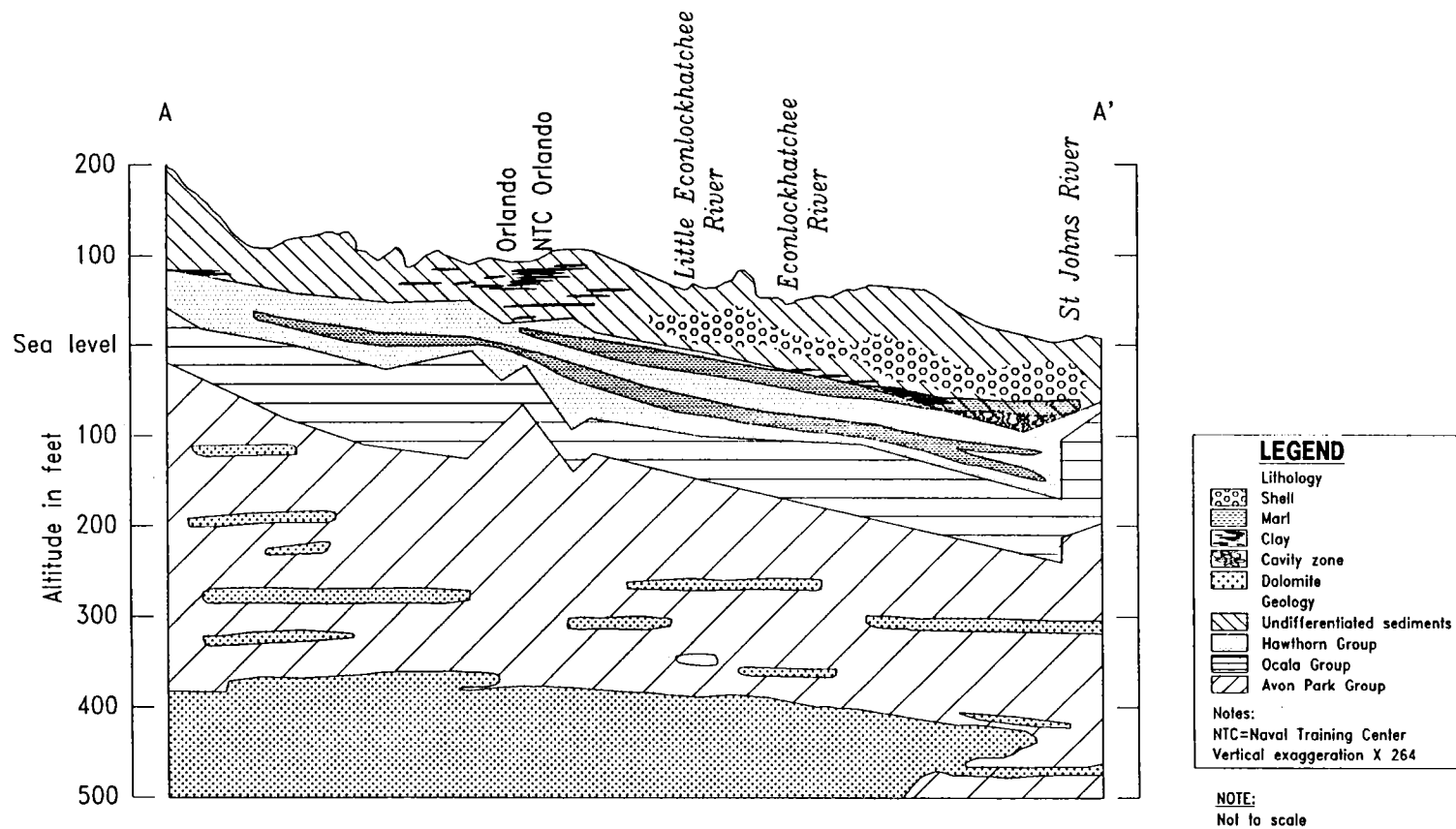
FIGURE 3-2
SURFACE WATER AND DRAINAGE MAP



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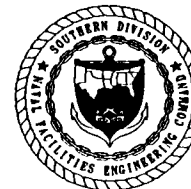
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Source:
Litchler, et al, 1968

FIGURE 3-5
REGIONAL GEOLOGIC CROSS SECTION



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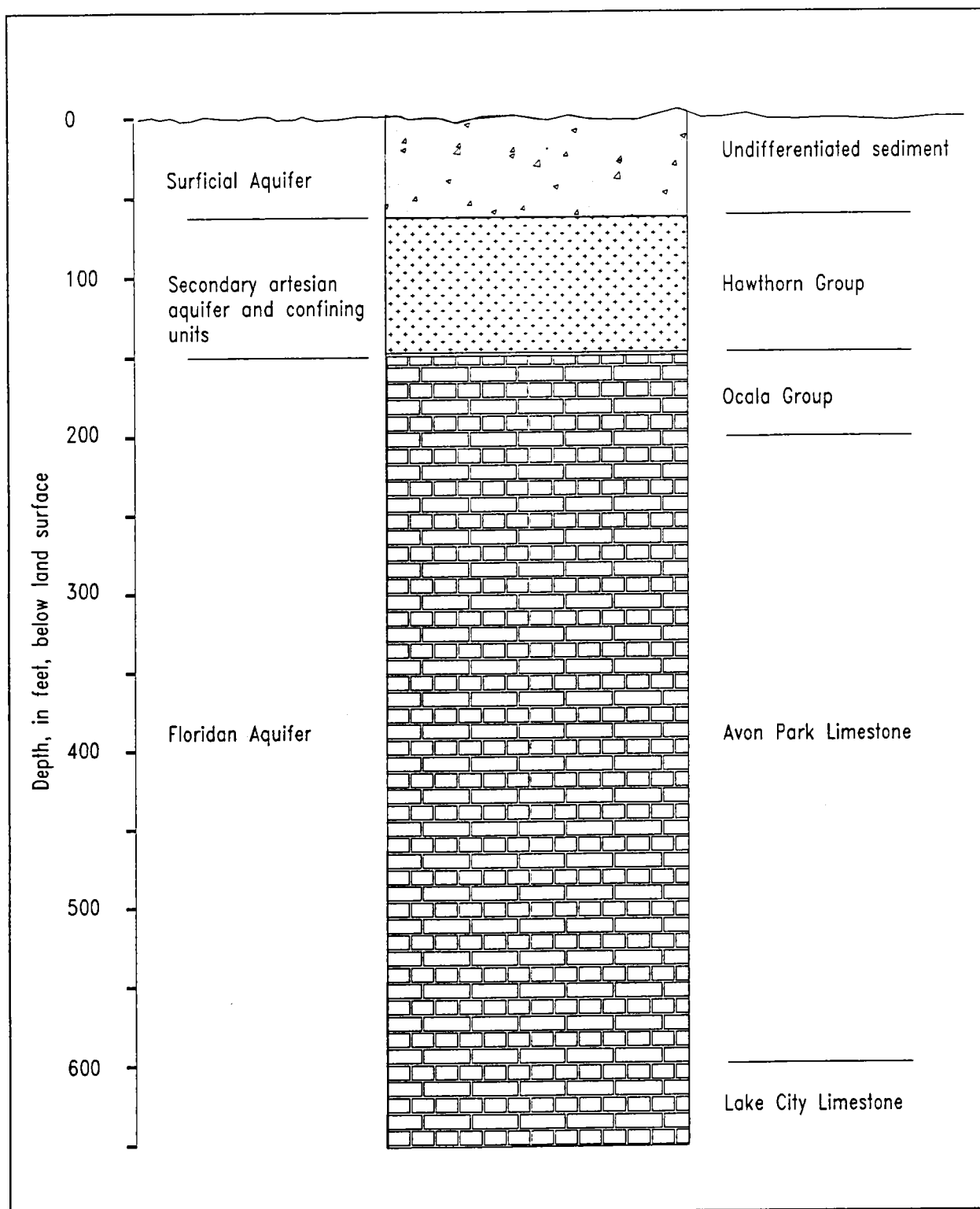


FIGURE 3-6
GENERALIZED HYDROSTRATIGRAPHIC COLUMN

Source: Litchler, et al, 1968



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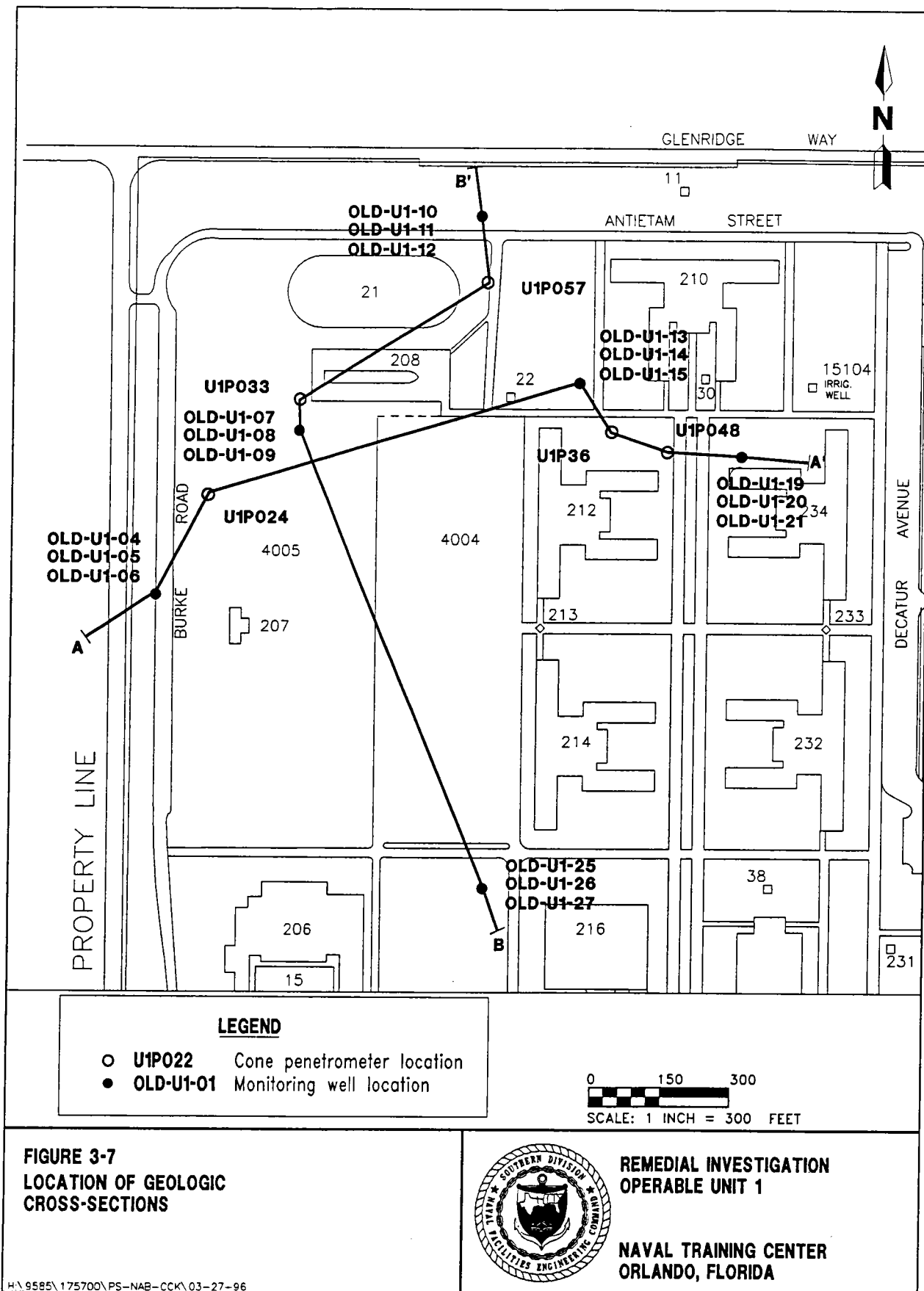
The upper part of the Hawthorn Group is generally divided into two units. The first is a greenish gray silty fine to coarse sand with phosphate nodules and shell fragments. This unit occupies the upper 10 to 15 feet of the Hawthorn Group in the study area. The second unit is a greenish gray silty clayey sand with intermingled layers of pure clay. This unit was penetrated from three to five feet.

The piezocone and SPT logs were used to measure the thickness of the undifferentiated surficial deposits (Figure 3-10). The surficial deposits are thickest in the southeast and northwest corners of the study area (55 to 60 feet thick) and thin to approximately 40 feet in the northeast. As the land surface is essentially flat across the study area, the isopach map represents the configuration of the surface of the Hawthorn Group. The surface is nearer to land surface, and hence at its highest elevation, where the deposits are thinner. Thus the surface of the Hawthorn has a high in the northeast corner and slopes toward the south and west.

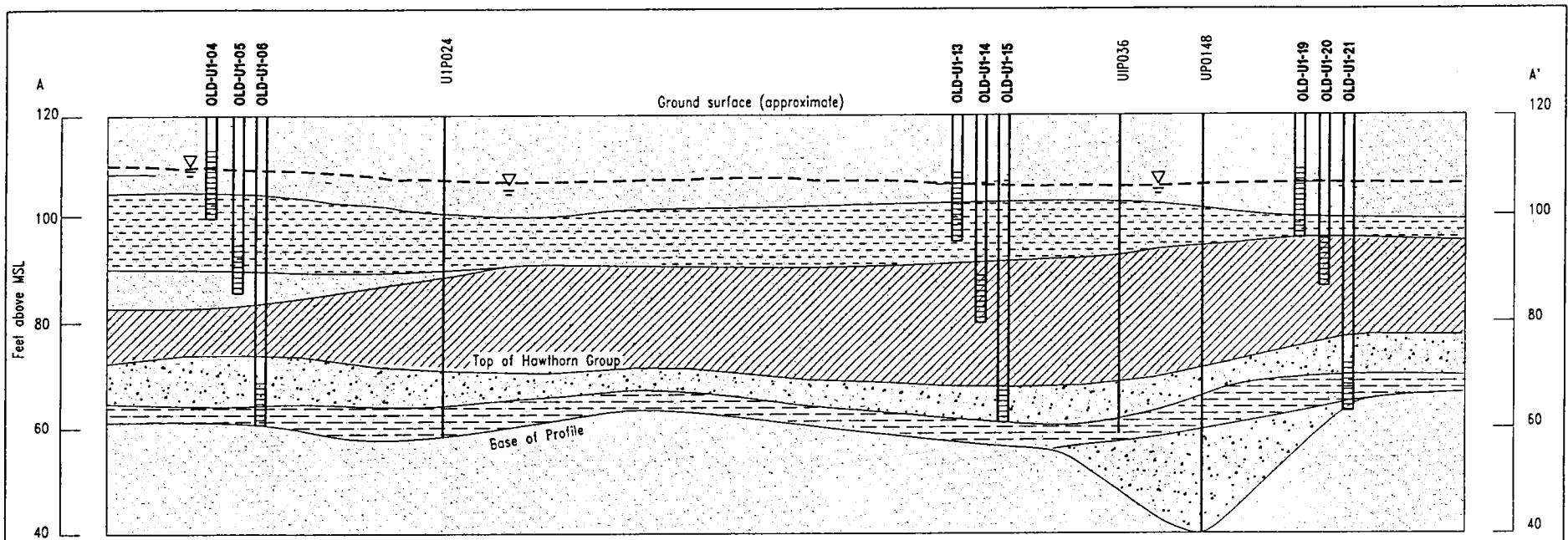
3.6 HYDROGEOLOGY.

3.6.1 Regional According to regional literature, three distinct aquifer systems corresponding to the three major stratigraphic divisions are found in this area of central Florida: the surficial aquifer, an intermediate aquifer, and the Floridan aquifer system. The surficial or, shallow, aquifer is an unconfined porous flow system within the unconsolidated surficial deposits. The intermediate aquifer occurs where the clastic deposits of the Hawthorn Group are sufficiently permeable for groundwater flow. The bedding planes, cracks, and fissures within the Eocene carbonate sequence provides space for the groundwater of the Floridan aquifer system (Figure 3-6). Each aquifer is summarized below. (The remainder of this section not included as it is considered nonessential for this submittal).

3.6.3 Site-Specific Hydrogeology The hydrogeology at OU1 was evaluated through preparation of potentiometric surface maps and permeability testing. These data were evaluated for the shallow, intermediate, and deep portions of the surficial aquifer.



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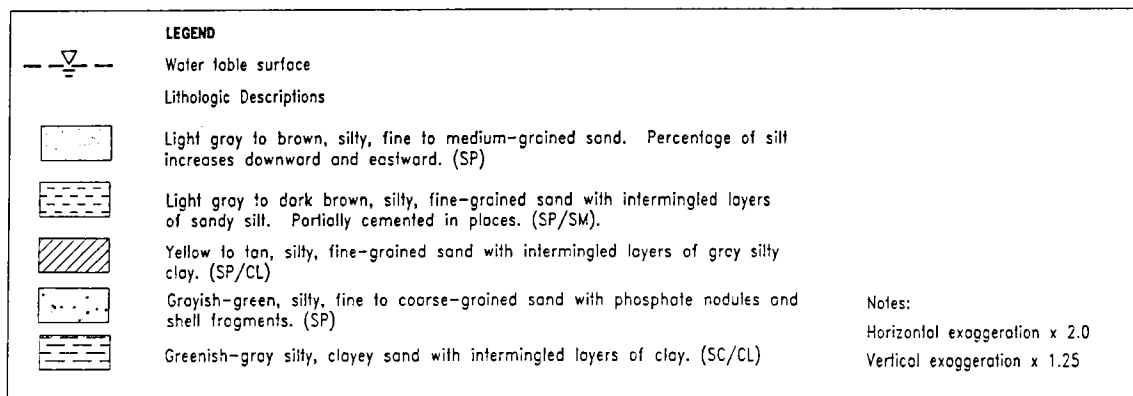
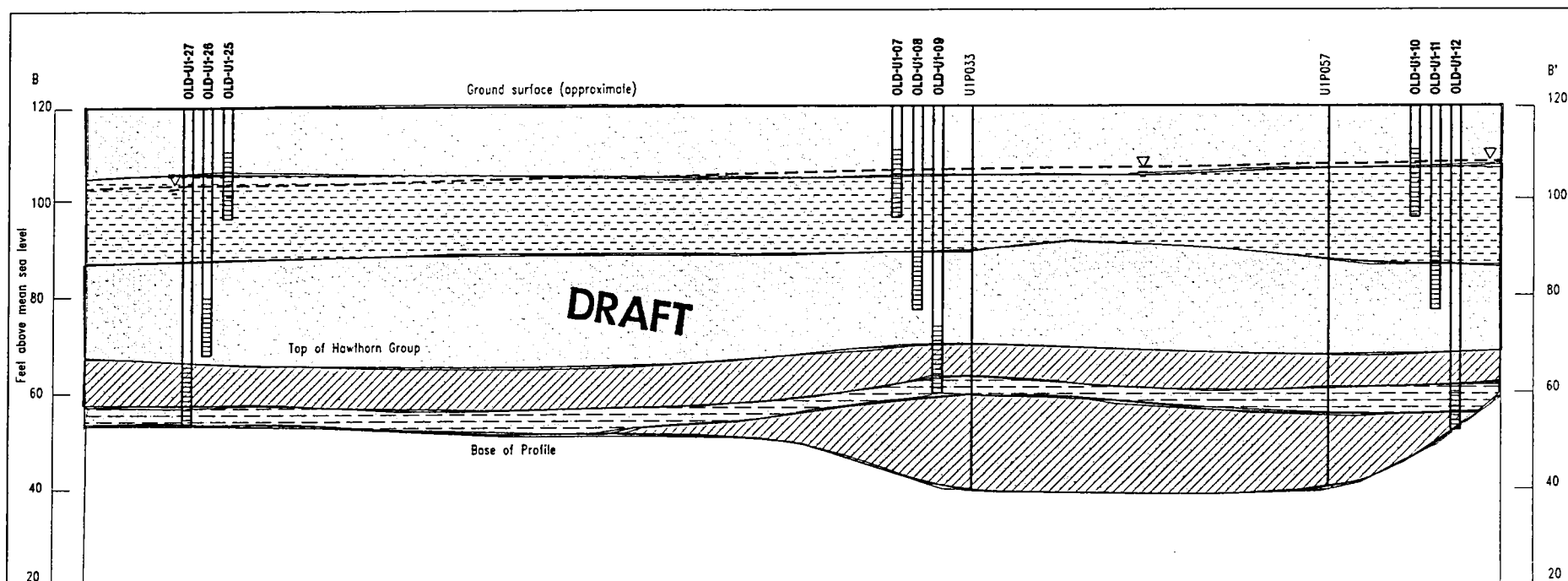
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FIGURE 3-8
EAST-WEST GEOLOGIC
CROSS-SECTION



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**FIGURE 3-9
NORTH-SOUTH GEOLOGIC
CROSS-SECTION**



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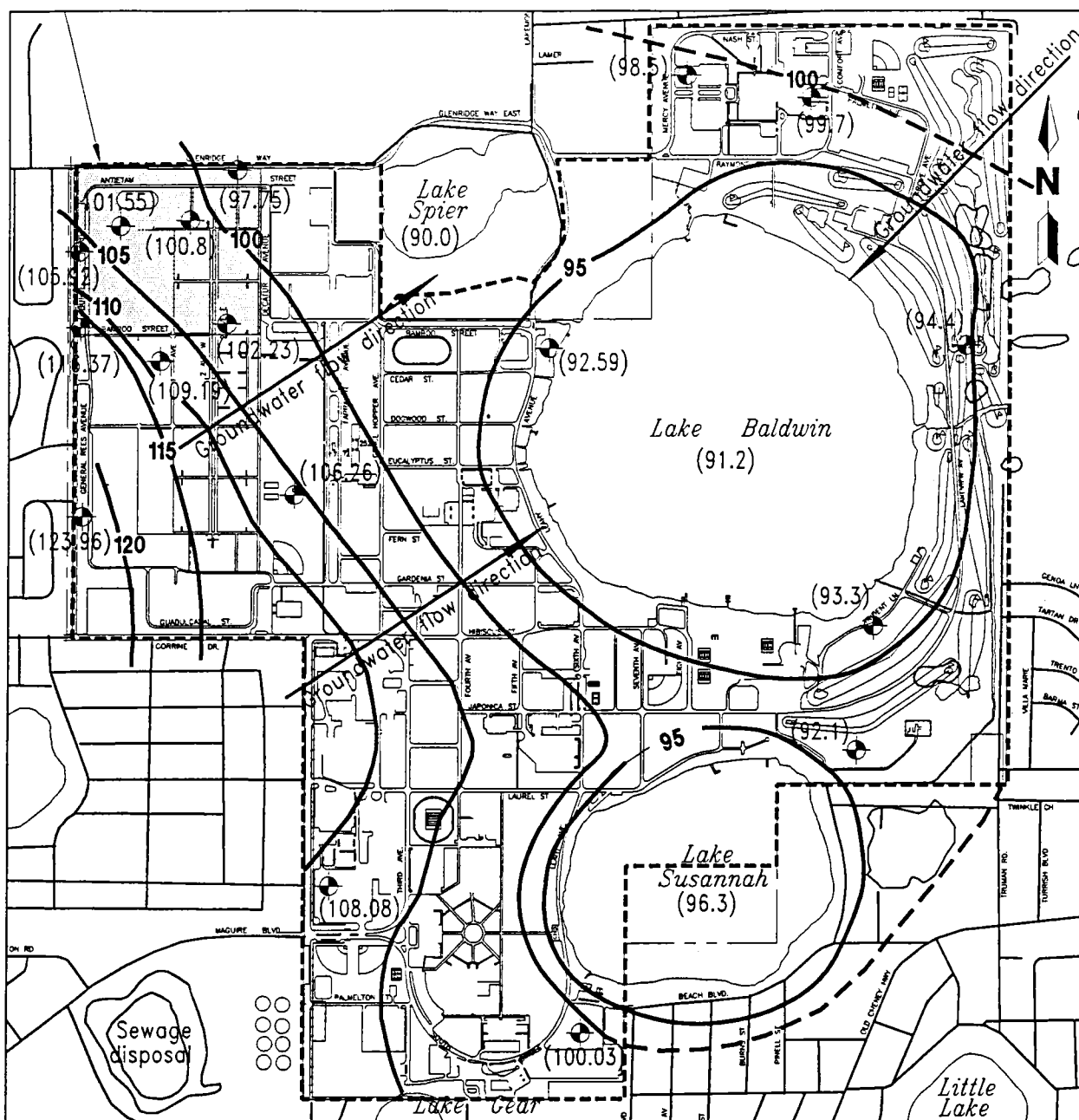
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3.6.3.1 Potentiometric Surface Mapping In order to identify surficial groundwater flow direction for the study area, water levels were measured at the monitoring wells installed at the study area. These data were used to map the potentiometric surface as depicted in Figure 3-11. The potentiometric surface generally mimics the topography of the area with the groundwater flow from the areas of the highest elevation along the west side of the base eastward toward Lake Baldwin and Lake Susannah. These lakes represent natural depressions in the potentiometric surface and groundwater flows toward them in a radial fashion. The configuration is consistent with that presented by published reports (Litchler, 1968).

In order to determine the seasonal variation of the potentiometric surface, water level measurements were collected monthly. The data collected from the shallow monitoring wells during August 1995 and January 1996 (Tables 3-1 and 3-2) were used to construct the potentiometric maps presented in Figures 3-12 through 3-17, respectively. The potentiometric maps present the groundwater contours for the shallow, intermediate, and deep portions of the surficial aquifer. These data sets were selected because they were collected in the summer and winter months six months apart and therefore should be representative of the potentiometric surface during at different points during the year.

A comparison of the potentiometric surface at its highest and lowest values indicates relatively little change in the lateral groundwater flow direction over time. For both cases, the groundwater flows generally in a north-northeast direction, with a more northerly flow on the south side of the area and northeasterly flow on the north side. The water level fluctuation in the wells on the south and west sides of the study area between seasons is more pronounced (1 to 2 feet on average) than in the wells to the north and east. This variation in water level range produces a variation in groundwater gradient with time, which alters the speed of groundwater flow through the area.

Water level data from the monitoring wells show the well clusters located along the south and west sides of the study area have a significant range (greater than 10 feet at some clusters) of water level elevations. When considered with the lithologic framework of the study area, these data suggest that finer-grained



LEGEND

- Monitoring well location
- (108.08) Groundwater level elevation (feet, mean sea level)
- 100 — Potentiometric surface contour, dashed where inferred

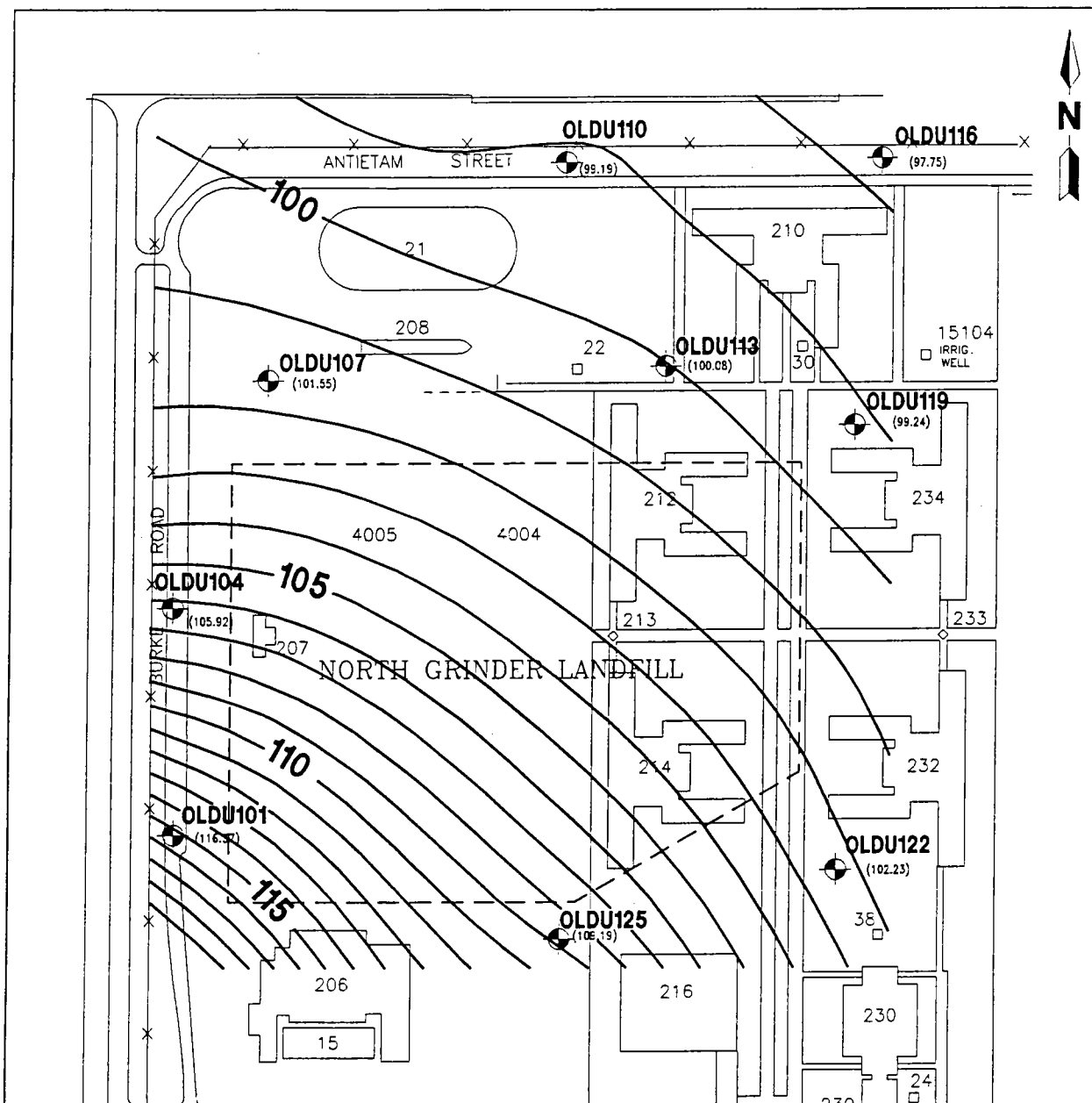
Note: Water level data collected August 1995

FIGURE 3-11
GENERALIZED POTENTIOMETRIC SURFACE MAP
OF SHALLOW GROUNDWATER AQUIFER



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0 150 300
SCALE: 1 INCH = 300 FEET

LEGEND

OLDU104 (105.92) Monitoring well location and designation with groundwater elevation in feet above mean sea level
 105 Groundwater elevation contour
 Landfill boundary

FIGURE 3-12
GROUNDWATER ELEVATION CONTOURS
UPPER PORTION OF SHALLOW AQUIFER
AUGUST 1995



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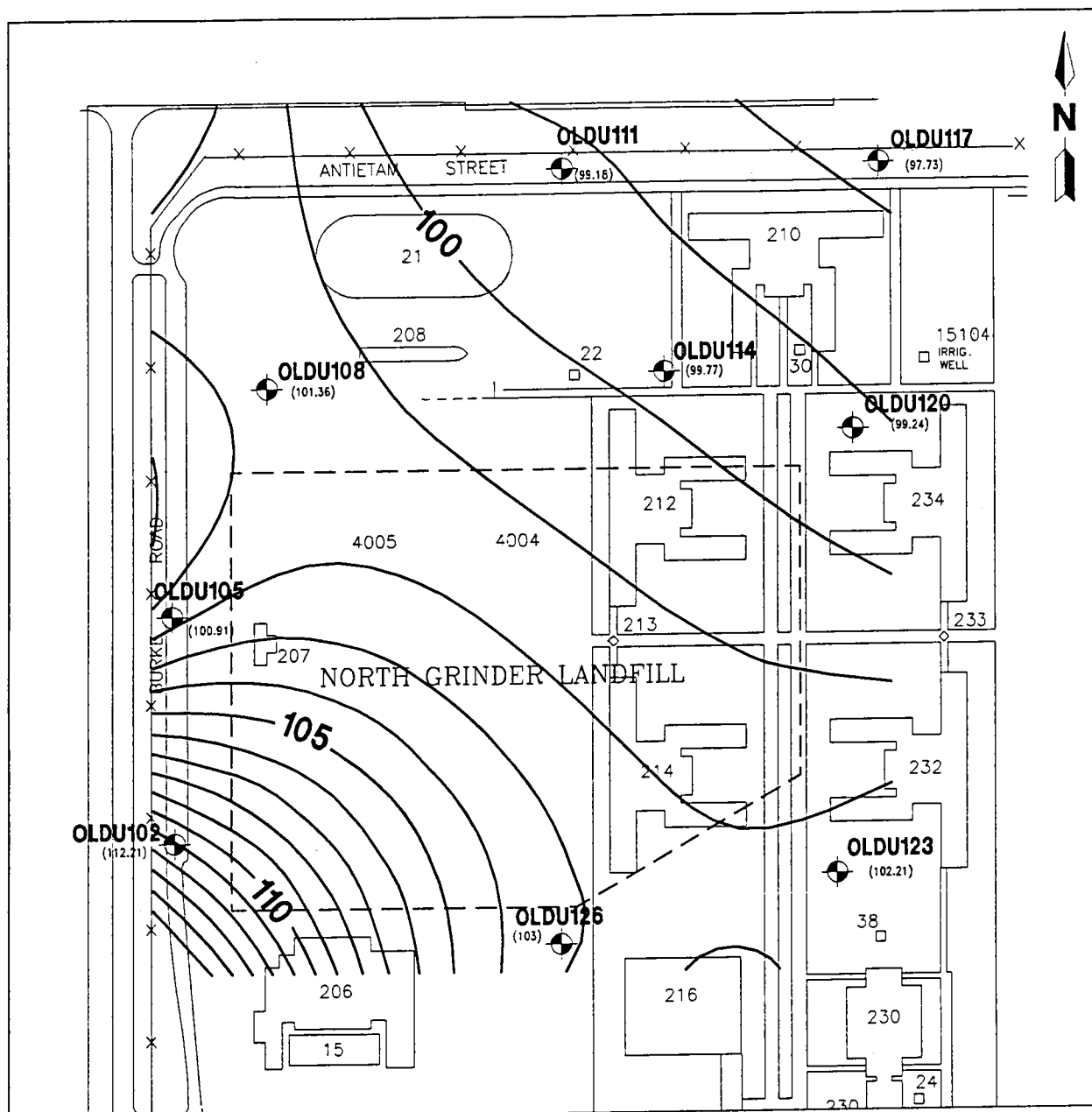
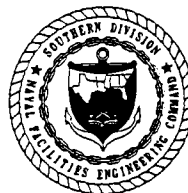
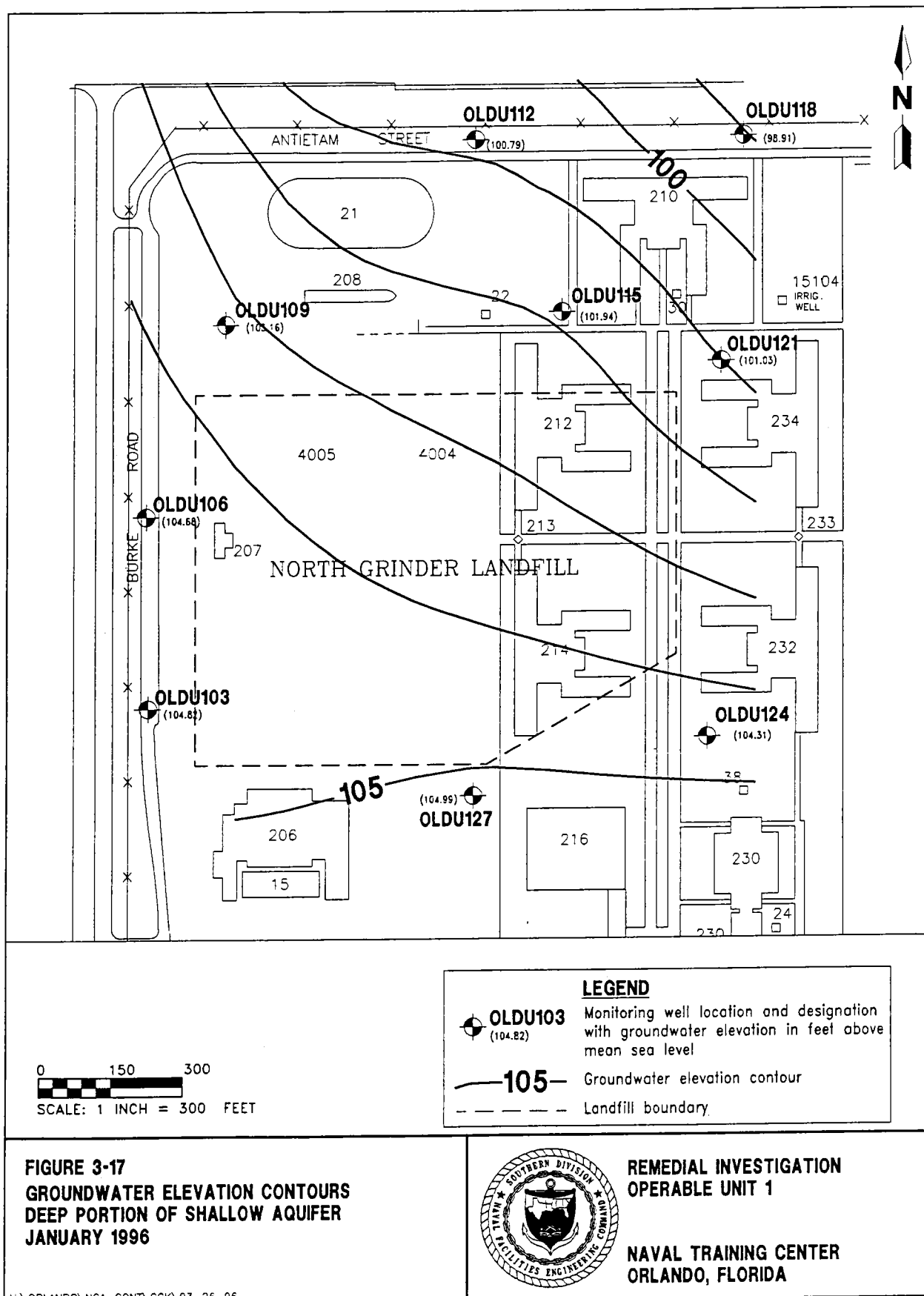


FIGURE 3-13
GROUNDWATER ELEVATION CONTOURS
INTERMEDIATE PORTION OF SHALLOW AQUIFER
AUGUST 1995



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sediments in the upper part of the surficial deposits are creating a perched water table condition to the southwest. The water level elevations in the deep wells of these clusters may more accurately reflect the actual elevation of the local potentiometric surface.

When the water level elevations are grouped by well completion interval, a variation in gradient is apparent. The shallow wells have relatively steep horizontal gradient of 0.0075 feet per foot (ft/ft). The gradient across the intermediate depth zone is approximately 0.0067 ft/ft, and the gradient across the deep zone is approximately 0.0038 ft/ft. Since the water level elevations of the shallow wells in the south and west may be influenced by perching, the deep well data may represent the closest estimate to the horizontal gradient across the study area.

3.6.3.2 Permeability Test Results Falling head (slug-in) and rising head (slug-out) tests were performed at each monitoring well where feasible, e.g., intermediate and deep wells. The rising head test results (Table 3-2) are discussed below. The results appear to be consistent with the lithologic framework of the area with higher values measured in wells screened in coarser-grained materials. The average permeability value for the rising head test performed at the shallow wells is 0.004493 feet per minute (ft/min). The average permeability value at the intermediate depth wells is 0.008448 ft/min, and at the deep wells the average value increased to 0.009459 ft/min.

The average hydraulic conductivity values can be used in conjunction with the average horizontal gradient to determine the flow velocity at the varying depths of the surficial aquifer. The flow rate calculations are based on the following equation (Bouwer and Rice, 1976):

$$V = Ki/p,$$

where: V = groundwater flow velocity (ft/min),
 K = hydraulic conductivity (ft/min),
 i = hydraulic gradient (ft/ft), and
 p = porosity (unitless), assuming .30 for sand aquifers (Fetter, 1980).

Using this formula, the average flow rate for the upper part of the surficial aquifer in the study area is estimated at 0.000112 ft/min. In the intermediate

depths of the aquifer the average velocity increases slightly to approximately .00018 ft/min. For the deeper portions of the aquifer the average velocity is .000119 ft/min. The higher calculated velocity in the intermediate zone reflects the steep horizontal gradient of the potentiometric surface and coarser-grained sediments improving hydraulic conductivity. The overall average for the surficial aquifer is 0.00014 ft/min in the study area. Assuming an average thickness of 50 feet for the surficial aquifer at OU 1, a transmissivity value of 625 square feet per day (ft²/day) was calculated.

The permeability test plots and calculations are provided in Appendix H.

3.7 DEMOGRAPHY AND LAND USE. (This section has been omitted because it is considered nonessential for this submittal).

3.8 ECOLOGICAL SETTING.

3.8.1 Terrestrial Habitat and Receptors (This section has been omitted because it is considered nonessential for this submittal).

3.8.2 Aquatic Habitat and Receptors (This section has been omitted because it is considered nonessential for this submittal).

3.8.3 Rare, Threatened, and Endangered Species (This section has been omitted because it is considered nonessential for this submittal).

4.0 NATURE AND EXTENT OF CONTAMINATION

This chapter focuses on the nature and location of contaminants in the existing landfill cover material and groundwater, and assesses whether contamination has migrated from the landfill source areas. This discussion uses the information discussed in the earlier sections on regional and site specific conditions (Chapter 3) and the physical and chemical data collected during the field investigations (Chapter 2).

All analytical data obtained from these investigations have been combined into a single, analytical database, following a review of data quality by means of data validation. Data quality indicators include the precision, accuracy, representativeness, completeness, and comparability (PARCC) of the analytical data on a per medium basis. In general, the combined data set complied with PARCC criteria and is considered acceptable for use in this RI and to support a potential feasibility study. The analytical data, including Sample Tracking Logs, Positive Detection Tables, Summary of Laboratory Analytical Tables, PARCC Reports, Statistical Evaluation, and Gross Radioactivity-Inorganic Comparisons are presented as Appendices I-1 through I-6, respectively.

The combined data set was also subjected to data evaluation. Data evaluation differs from data validation in that the latter deals only with the adherence of the analytical process to protocol specifications, whereas data evaluation considers the environment from which the analyzed sample was collected, the means of collection, as well as the characteristics of data considered to be within the same data set and knowledge of the compound's behavior in the area of the investigation. Data evaluation included the following:

- Evaluation for the presence of chemicals which may not be true detections and may have been introduced during decontamination, field sampling or laboratory analysis (analytical and sampling artifacts). These chemicals include acetone, methylene chloride, toluene, 2-butanone, and five phthalate esters (butylbenzylphthalate, di-n-butylphthalate, di-n-octylbutylphthalate, diethylphthalate, and bis(2-ethylhexyl)phthalate) (USEPA, 1991b; 1988a). These contaminants, when analytical artifacts,

4.2 SOURCES OF CONTAMINATION. A full account of the known history of the facility and the land use of the area comprising OU 1 are presented in the Background Section (1.2), but the types of wastes disposed in the landfill and burned in the fire training pit are discussed in more detail as potential sources of contamination below.

The types of contaminants of concern within OU 1 are polyaromatic hydrocarbons (PAHs) in the surface soil comprising the landfill cover material, and radioisotopes in the groundwater.

The types of documented wastes deposited in the landfill include film and photographic chemicals, paint thinner, garbage and trash, medical waste, yard and construction debris, and PCE stillbottoms. The petroleum products typically used by the military fire department for fire fighting drills included diesel fuel and aviation fuel.

4.3 CONTAMINATION ASSESSMENT.

4.3.1 Soil Vapor Two phases of investigation were completed during site screening activities to answer questions regarding potential contamination related to landfill gas generation. These are a passive soil gas survey over the landfill and an active soil gas survey around the landfill perimeter. The results are discussed below.

4.3.1.1 Passive Soil Gas Survey A passive soil gas survey was completed over the landfill footprint for the purpose of

- characterizing chemicals of potential concern (CPCs) present in the soil cover so that a proper soil gas collection system could be designed (if needed) and to allow for proper cap design;
- characterizing volatile and semivolatile constituents that have migrated to the landfill soil cover to locate potential "hot spots", which may need to be evaluated with regards to source removals to support remedial alternatives; and

- evaluate the presence of methane, which may still be problematic despite the age of the landfill.

A total of 303 passive soil gas collectors and 14 QA/QC duplicates were installed (Figure 2-6) on fifty-foot centers over the landfill area, except in cases where obstructions were encountered (i.e., buildings, impenetrable soil, buried utilities). The results of the passive soil gas survey are presented in Appendix D-1. Low to very low levels of petroleum hydrocarbons are present at scattered locations across the site, but do not suggest the presence of a significant petroleum hydrocarbon contamination problem in the shallow subsurface of OU 1. Chlorinated hydrocarbon contamination was not evident at the site.

4.3.1.2 Active Soil Gas Survey An active soil gas survey was conducted at OU 1, which consisted of installing and sampling soil vapor implants around the perimeter of the landfill. The objective was to evaluate the presence and potential lateral migration of methane and other landfill gases generated by landfilled materials. Landfill gas collection and treatment is an important consideration of source containment under the presumptive remedy.

Sixty active soil gas sampling implants were installed around the perimeter of the landfill (Figure 2-4). The implants were spaced at approximately 50-foot intervals, except in the northeast and southeast corners, where buildings prevented implant placement.

The results of the gas sampling at these implant locations are summarized in Appendix D-2. Sixteen samples had analytes that were detected on the field GC, but all of the detections were at very low concentrations. Methane screening was performed at each of the soil vapor implant locations, and there were no methane detections.

4.3.2 Surface Soil To assess the quality of the landfill cover, 14 surface soil samples (plus 2 duplicates) were collected for laboratory analysis. The sample locations were based on one sample per acre coverage. Positive detections in the analytical results are discussed in paragraphs 4.3.2.1 through 4.3.2.5. Positive detection tables are provided in Appendix I-2.1 and I-2.2. The complete laboratory result summaries are provided in Appendix I-3. Interpretation of the

analytical data in terms of possible sources and extent of compounds exceeding background using the statistical population comparisons is discussed in paragraph 4.3.2.6. In order to focus the discussion on detected analytes or compounds which are site-related, a preliminary comparison to FDEP soil cleanup goals (SCGs) was made.

4.3.2.1 Volatile Organics Acetone was detected in 15 of 16 surface soil samples (including two field duplicates) at concentrations ranging from 6 to 18 micrograms per kilogram ($\mu\text{g}/\text{kg}$) (Table 4-1 and Appendix I-2.1). This compound, however, appears to be an analytical artifact, as it is highly unlikely that this compound is present in surface soils due to its high volatility and because no other related volatile organic contaminant is present (e.g., other ketones). There are no other volatile organic compound detections.

4.3.2.2 Semivolatile Organics PAHs were detected above background levels in surface soil samples primarily from three adjacent locations (S004, S005 and S010). Related single PAH compounds were also detected below contract required quantitation limits (CRQLs) in samples from S002 and S003 (Table 4-1 and Appendix I-2.1). Statistical analysis of detected levels of PAH compounds in the OU 1 surface soil and background data set indicate no significant differences in the OU 1 and background populations (Appendix I-5). However, statistics indicated that the Benzo(a)pyrene detections in S004 ($400 \mu\text{g}/\text{kg}$) and S010 ($1200 \mu\text{g}/\text{kg}$) are outside values which indicate a localized occurrence of PAH contamination in these locations. The PAH contamination is believed to be site-related because of the historical use of the site (the firefighter training pit) and the spatial relation between those sample locations and their proximity to the firefighter training pit. For purposes of comparison, only benzo(a)pyrene and dibenz(a,h)anthracene concentrations in the sample from S010 exceed the industrial SCGs (Figure 4-1), with the former compound exceeding the industrial RBC as well.

4.3.2.3 Pesticides and Polychlorinated Biphenyls Several pesticide compounds were detected primarily at low levels in 12 of 16 surface soil samples (Table 4-1 and Appendix I-2.1). They include 4,4-DDT and its degradation products, 4,4-DDD and 4,4-DDE, alpha-chlordane and gamma-chlordane, dieldrin, gamma-BHC (Lindane), and heptachlor epoxide. A polychlorinated biphenyl (PCB) compound, Aroclor-1260, was also detected in 7 samples from 6 locations (S001, S002, S007, S008, S009,

and S013) at concentrations ranging from 35 to 150 $\mu\text{g}/\text{kg}$. Statistically, 5 of 7 Aroclor-1260 detections were identified as outside values, indicating site-related contamination.

Population comparisons of these detections indicate that, except for alpha-Chlordane and gamma-Chlordane, which are significantly higher in the OU 1 data set (Table 4-2), these compounds are not significantly higher than the background population set. All detections, however, do not exceed the industrial scenario SCGs.

4.3.2.4 Herbicides There were no herbicides detected in surface soil samples.

4.3.2.5 Inorganics One or more inorganics were detected above background levels in 13 of 16 surface soil samples, all of which are expected to be present naturally in the soil (Table 4-1 and Appendix I-2.2). Of the detected inorganics, arsenic, calcium, chromium, copper, magnesium and zinc are statistically higher in OU 1 than the background data set, indicating that they are site-related (Table 4-2). Cadmium, silver, potassium, and thallium were also found to be from different populations, but because many of the samples are below detection limits, these differences mostly reflect the variation in the reported detection limits between the two groups. It appears, however, that only cadmium and silver are site-related because the outside values exceed the highest background detection. For purposes of comparison, none of these detections exceed the industrial scenario SCGs.

Table 4-1
Summary Statistics of Detected Analytes/Compounds in Surface Soil Samples

Remedial Investigation Report, Operable Unit 1
 North Grinder Landfill
 Naval Training Center
 Orlando, Florida

Parameter	Min. De- tection Limit	Max. Detection Limit	Min. Detected Level	Max. De- tected Level	Average Positive Detections	No. Det/ Total No. Samples	Background Screening Value
Inorganics, mg/kg							
Aluminum	N/A	N/A	182	1,200	618.688	16/16	2,088
Arsenic	0.38	0.4	0.42	2.9	1.408	11/16	1.04
Barium	N/A	N/A	0.96	19.1	7.335	16/16	8.7
Cadmium	0.62	0.66	0.8	2.1	1.38	5/16	0.98
Calcium	N/A	N/A	305	119,000	30,112.875	16/16	25,295
Chromium	N/A	N/A	1.1	26.8	7.194	16/16	4.6
Copper	0.28	1.6	2.3	15.2	8.07	10/16	4.1
Iron	N/A	N/A	109	944	338.625	16/16	712
Lead	N/A	N/A	1.4	24.3	8.5	16/16	14.5
Magnesium	20.7	21.5	59.5	922	291.943	14/16	328
Manganese	N/A	N/A	1.5	11.7	6.088	16/16	8.1
Mercury	0.02	0.02	0.02	0.74	0.155	11/16	0.07
Potassium	89.3	122	105	105	105	1/16	157
Silver	0.52	3.4	3.3	6	4.267	3/16	1.8
Thallium	0.38	0.45	0.39	0.39	0.39	1/16	2
Vanadium	0.51	1.3	0.54	5.8	2.175	13/16	3.1
Zinc	N/A	N/A	2.6	60.1	22.925	16/16	17.2
Volatile Organics, µg/kg							
Acetone	10	10	6	18	8.8	15/16	--
Semivolatile Organics, µg/kg							
Acenaphthene	340	350	100	100	100	1/16	--
Anthracene	340	350	130	130	130	1/16	--
Benzo(a)anthracene	340	350	120	480	263.333	3/16	--
Benzo(a)pyrene	340	350	200	1,200	600	3/16	--
Benzo(b)fluoranthene	340	350	250	410	330	2/16	--
See notes at end of table							

Table 4-1 (Continued)
Summary Statistics of Detected Analytes/Compounds in Surface Soil Samples

Remedial Investigation Report, Operable Unit 1
 North Grinder Landfill
 Naval Training Center
 Orlando, Florida

Parameter	Min. De- tection Limit	Max. Detection Limit	Min. Detected Level	Max. De- tected Level	Average Positive Detections	No. Det/ Total No. Samples	Background Screening Value
Semivolatile Organics, $\mu\text{g/kg}$							
Benzo(g,h,i)perylene	340	350	120	2,500	797.5	4/16	100
Benzo(k)fluoranthene	340	350	210	4,000	1,533.333	3/16	--
bis(2-Ethylhexyl)phthalate	340	350	190	280	226.667	3/16	--
Carbazole	340	350	93	93	93	1/16	--
Chrysene	340	350	210	500	326.667	3/16	--
Dibenz(a,h)anthracene	340	350	120	760	440	2/16	--
Fluoranthene	340	350	93	1,100	450.75	4/16	--
Indeno(1,2,3-cd)pyrene	340	350	160	2,300	913.333	3/16	--
Phenanthrene	340	350	150	620	385	2/16	--
Pyrene	340	350	160	1,000	530	3/16	--
Pesticides/PCBs $\mu\text{g/kg}$							
4,4'-DDD	3.4	18	3.5	3.5	3.5	1/16	--
4,4'-DDE	3.4	3.5	1.8	43	15.444	9/16	39.2
4,4'-DDT	3.4	3.5	2	48	15.929	7/16	22.8
alpha-Chlordane	1.7	1.8	1.1	85	26.592	12/16	6.1
gamma-Chlordane	1.7	1.8	1	53	18.682	11/16	4.3
Dieldrin	3.4	3.5	3.8	180	70.863	8/16	--
gamma-BHC (Lindane)	1.7	9.2	1.2	1.2	1.2	1/16	--
Heptachlor epoxide	1.7	1.8	4.3	7.2	6.175	4/16	--
Aroclor-1260	34	35	35	150	83.143	7/16	--
Total Petroleum Hydrocarbons (mg/kg)	N/A	N/A	10.1	96.6	35.944	16/16	--

Notes:

Num.Det/Tot.Sample = Number of detects / total number analyzed.

NA = Not applicable.

B = Reported sample concentration is between the instrument detection limit (IDL) and the contract required detection limit (CRDL).

J = Reported concentration is an estimated quantity.

U = Analyte/compound was not detected at the reporting limit.

Table 4-2
Summary of Population Comparisons on OU 1 Versus Background Surface Soil
Analytical Results

Remedial Investigation Report, Operable Unit 1
 North Grinder Landfill
 Naval Training Center
 Orlando, Florida

Parameter	Population statistical summary
Arsenic	OU 1 population higher
Calcium	OU 1 population higher
Chromium	OU 1 population higher
Copper	OU 1 population higher
Magnesium	OU 1 population higher
Zinc	OU 1 population higher
alpha-Chlordane	OU 1 population higher
gamma-Chlordane	OU 1 population higher
Cadmium	Different populations but comparison largely driven by detection limit differences; OU 1 data set has four detections exceeding the background range; considered site-related.
Silver	Different populations but comparison largely driven by detection limit differences; OU 1 data set has three detections exceeding background range; considered site-related.
Potassium	Different populations but comparison largely driven by detection limit differences; OU 1 data set has only one detection; not considered site-related.
Thallium	Different populations but comparison largely driven by detection limit differences; OU 1 data set has one detection within the range of background; not considered site related.
<p>Notes:</p> <p>See Appendix I-5 for details on these population comparisons. "Detection limit differences" means that numerous data points in both data sets are below detection limits and therefore the population differences may be attributed primarily to the differences in detection limits and not the few actual detections. Acetone was found to be significantly higher in the background data set because most OU 1 detections are below CRQLs; however this compound is considered a field and/or laboratory artifact. Aluminum was also found to be significantly higher in the background data set.</p> <p>CRQL = Contract Required Quantitation Limit</p>	

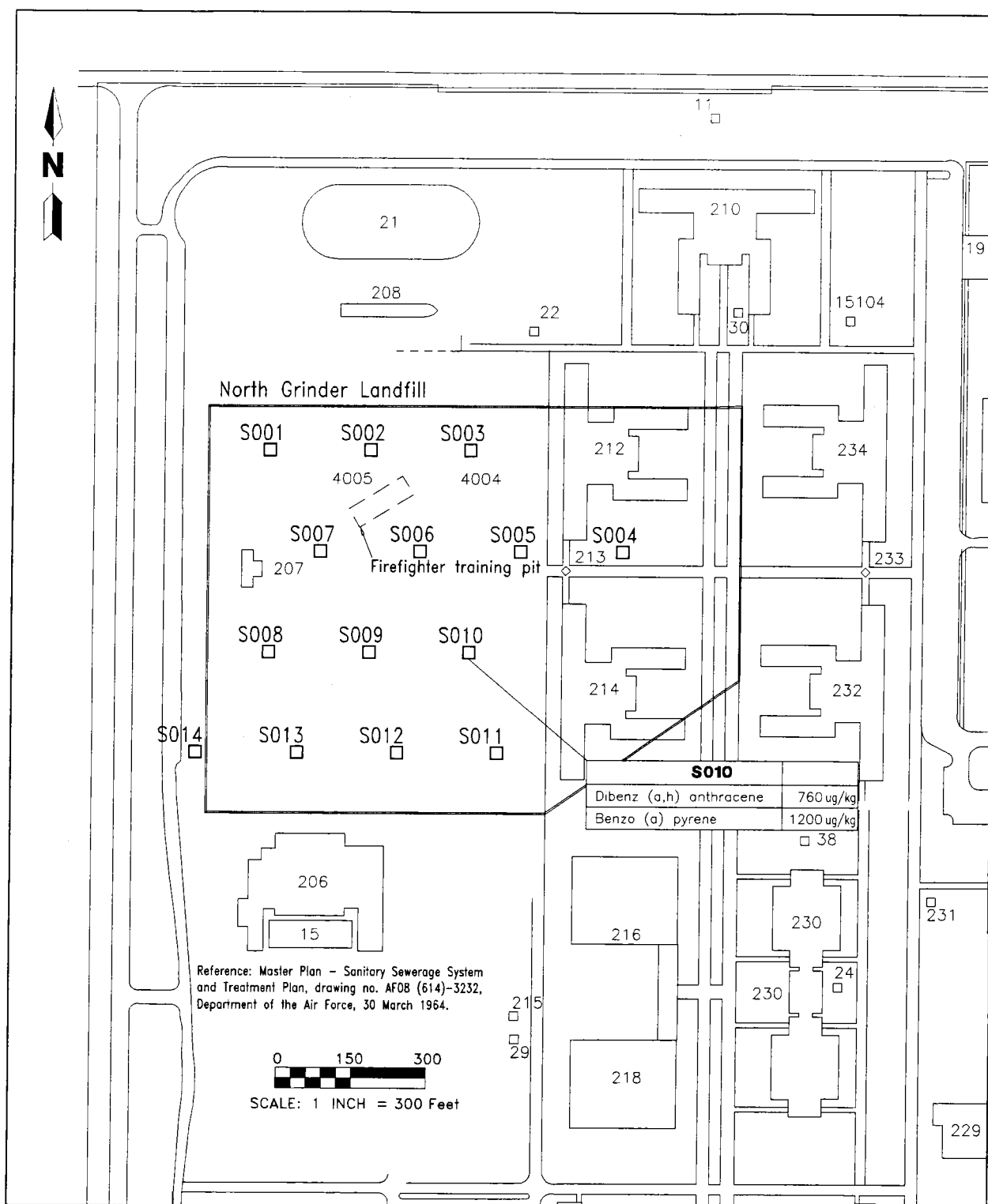
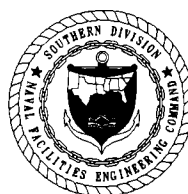


FIGURE 4-1
LOCATION OF DETECTED COMPOUNDS IN
SURFACE SOIL EXCEEDING INDUSTRIAL SOIL
CLEANUP GOALS (SCGs)



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4.3.2.6 Interpretation of Surface Soil Data Contaminants detected in surface soil samples collected in the landfill cover material primarily included pesticides and a PCB compound, inorganics, and PAHs. When compared to background, all these contaminants are site related, occurring as outside values. However, statistically, these contaminants are not significantly different from the background population, except for a few inorganics (arsenic, calcium, chromium, copper, magnesium and zinc) and two pesticides (alpha-Chlordane and gamma-Chlordane).

Pesticide detections at low parts per billion concentrations appear to indicate a systematic use of pesticides on the parade field because of its land use. PCB detections at low parts per billion concentrations were detected in surface soil samples collected across the grass-covered parade field, but not under the asphalt-covered portion. This indicates that oil with PCB concentrations may have been applied to the area after the asphalt was laid, possibly as a means of controlling dust before the field was sodded.

The inorganics detected above background that statistically appear to be site-related are probably connected to the systematic use of pesticides and fertilizers on the parade field.

It is not unusual to find detectable levels of PAHs in urban surface soil environments, mainly originating from high temperature combustion sources such as automobile exhausts, urban fires, and boilers. However, the sample locations where PAHs were detected are grouped together as opposed to being randomly scattered throughout OU 1. The fact that three locations are in close proximity to the east side of the old fire training pit, and two locations are to the north of the pit, suggests a relationship (S004, S005, and S010, and S002 and S003, respectively; see Figure 4-1). The PAH contamination may be derived from either windblown ash from burning flammable materials in the fire pit (the prevailing winds are westerly and southerly), or from earth moving during the development of the parade field, which may have spread the remnant of contaminated soil away from the pit. The lighter volatile organics associated with petroleum products used by the military fire department, such as BTEX or naphthalenes, were not detected.

Another potential source of PAHs considered was from leaching of the asphalt pavement above two of the sample locations. However, samples were collected beneath asphalt at four other locations where no PAHs were detected, and there is no asphalt at sample locations S002, S003, or S004. The asphalt pavement, acting as an impermeable cap, has more likely contributed to the prevention of both man-made or vegetative disturbances of the topsoil, and leaching of contaminants by surface water infiltration.

4.3.3 Groundwater The groundwater was initially screened using DPT and a field gas chromatograph (GC) to strategically place the monitoring well clusters. A total of 151 groundwater samples were collected from depths ranging from 6 to 70 feet bls (Appendix B). Ten of these samples were sent to an offsite laboratory for confirmation of the GC results with CLP methodology. Appendix B provides a summary of the groundwater screening studies by DPT, along with the field GC and confirmation laboratory results. Based on the groundwater screening results, nine monitoring well clusters (27 wells) were installed and sampled for laboratory analysis. Positive detections in the analytical results for 30 unfiltered (and 30 filtered) groundwater samples, including 3 field duplicates, are discussed in sections 4.3.3.1 through 4.3.3.7, and positive detection tables are provided in Appendix I-2.3 through I-2.5. The complete laboratory results are provided in Appendix I-3. Interpretation of the groundwater analytical data in terms of possible sources and extent of compounds exceeding background and/or MCLs is discussed in section 4.3.3.8.

4.3.3.1 Volatile Organics During groundwater field screening by DPT (Appendix B), 148 samples were analyzed by a portable GC for volatile organics compounds (VOCs), which included benzene, toluene, ethylbenzene, m-xylene, o-xylene, TCE, PCE, and DCA. With the exception of five locations, most of the detected VOCs were below Federal MCLs. The detected contaminants with concentrations at or exceeding MCLs were limited to benzene at two locations on the south side of the landfill (9.7 $\mu\text{g}/\text{l}$ at U1P01902 and 7.5 $\mu\text{g}/\text{l}$ at U1P05002), and tetrachloroethylene (PCE) at three locations along the west side (5.2 $\mu\text{g}/\text{l}$ at U1P00202, 5.0 $\mu\text{g}/\text{l}$ at U100302, and 7.3 $\mu\text{g}/\text{l}$ at U1P00401). Ten samples were also sent to a laboratory for confirmation, which confirmed the portable GC analysis.

The groundwater screening results indicated two zones of minor VOC contamination (Figure 6 of Appendix B). BTEX (26.5 µg/ℓ) was detected in sample U101902, which was collected near a UST at Building 206. This UST was subsequently closed and found to be clean; therefore, a probable source for the detected petroleum constituents is a surface spill from a fuel truck. The analytical results from the groundwater screening survey (field GC and laboratory) are included in Appendix B.

VOCs detected by laboratory analyses of groundwater samples collected from the installed monitoring wells include acetone, carbon disulfide and chlorobenzene (Table 4-3). Acetone appears to be a sampling and/or analytical artifact as there is no reason to believe it is present without the presence of similar compounds (e.g., other ketones). Carbon disulfide is only present in one sample from a deep well (OLD-U1-27). BTEX constituents and PCE were not detected in any of the groundwater samples. Detected VOCs do not exceed their respective FDEP guideline values or tap water RBCs (Appendix I-2.3).

4.3.3.2 Semivolatile Organics Semivolatile organic compounds detected in groundwater include 1,4-dichlorobenzene, bis(2-ethylhexyl)phthalate, dimethylphthalate, naphthalene and phenol (Table 4-3). Concentrations of all these compounds, except bis(2-ethylhexyl)phthalate, do not exceed FDEP guidelines or tap water RBCs. The exception is considered a common laboratory artifact.

4.3.3.3 Pesticides and PCBs One pesticide compound, 4,4-DDT, was detected at 0.06 µg/ℓ in one shallow groundwater well (OLD-U1-25). This detection does not exceed its FDEP guideline or tap water RBC (0.2 ug/ℓ).

4.3.3.4 Herbicides One herbicide compound, 2,4-D was detected at 3.4 µg/ℓ in one shallow groundwater well (OLD-U1-01). This detection does not exceed FDEP guidelines (MCL) or tap water RBC (61 ug/ℓ).

4.3.3.5 Inorganics One or more inorganics were detected in 14 of 30 unfiltered groundwater samples at concentrations above background screening levels (Table 4-3 and Appendix I-2.4). The samples with the higher number of exceedances (3 to 12 inorganics) came from intermediate and deep wells (OLD-U1-03, -06, -15, -17,

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-26, and -27). As there is a noticeable increase in certain inorganics with depth in the

Table 4-3
Summary Statistics of Detected Analytes/Compounds in Groundwater Samples

Remedial Investigation Report, Operable Unit 1
 North Grinder Landfill
 Naval Training Center
 Orlando, Florida

Parameter	Min. Detection Limit	Max. Detection Limit	Min. De- tected Level	Max. Detected Level	Average Positive Detections	Num Det./ Total No. Samples	Back- ground
<u>Unfiltered Groundwater</u>							
<u>Inorganics, µg/l</u>							
Aluminum	24.7	24.7	62.4	35,700	2,741.643	28/30	4,067
Arsenic	1.5	14.8	14	14	14	1/30	5.0
Barium	0.5	6.1	3.6	596	59.985	27/30	31.4
Beryllium	0.2	0.2	0.21	7.1	2.438	6/30	--
Cadmium	2.4	2.4	4.2	4.2	4.2	1/30	5.6
Calcium	15.7	15.7	1,860	128,000	17,941.429	28/30	36,830
Chromium	2	13	2.5	61.2	12.713	8/30	7.8
Copper	1.4	3.2	1.4	6	2.869	13/30	5.4
Iron	6.1	6.1	9.4	7,870	1,141.042	26/30	1,227
Lead	1.3	3.2	1.5	6	3.22	5/30	4.0
Magnesium	28	28	428	4,550	1,893.893	28/30	4,560
Manganese	0.5	2.1	0.86	116	14.783	26/30	17.0
Mercury	0.04	0.15	0.04	0.06	0.048	5/30	0.12
Potassium	403	403	444	28,100	3,961.897	29/30	5,400
Selenium	0.6	1.6	0.9	3.5	2.083	6/30	9.7
Sodium	220	231	1,550	46,700	11,977.5	28/30	18,222
Vanadium	2.9	2.9	3.7	104	15.954	13/30	20.6
Zinc	1.2	5.2	1.2	42.6	6.525	16/30	4.0
<u>Volatile Organics, µg/l</u>							
1,4-Dichlorobenzene	10	10	1	8	2.4	5/30	--
Acetone	10	15	4	46	22.667	3/30	--
Carbon disulfide	10	10	4	7	5.5	2/30	--
Chlorobenzene	10	10	4	5	4.333	3/30	--
<u>Semivolatile Organics, µg/l</u>							
bis(2-Ethylhexyl)phthalate	10	10	2	30	7.667	6/30	--
Dimethylphthalate	10	10	7	7	7	1/30	--
Naphthalene	10	10	3	3	3	1/30	--
Phenol	10	10	1	1	1	1/30	--
<u>Pesticides, µg/l</u>							
2,4-D	2.5	2.5	3.4	3.4	3.4	1/30	--
4,4'-DDT	0.1	0.1	0.055	0.055	0.055	1/30	--
See notes at end of table							

Table 4-3 (Continued)
Summary Statistics of Detected Analytes/Compounds in Groundwater Samples

Remedial Investigation Report, Operable Unit 1
North Grinder Landfill
Naval Training Center
Orlando, Florida

Parameter	Min. Detection Limit	Max. Detection Limit	Min. De- tected Level	Max. Detected Level	Average Positive Detections	Num Det./ Total No. Samples	Back- ground
<u>Unfiltered Groundwater (Cont.)</u>							
Radiological, pCi/l							
Gross Alpha	1	1	1.6	257	22.387	30/34	13
Gross Beta	3	3	3.4	240	29.742	33/34	9.5
Cesium-137	N/A	N/A	-0.972	0.038	-0.431	4/4	NA
Potassium-40	N/A	N/A	5.88	28.4	14.805	4/4	NA
Radium-226	N/A	N/A	0	8.83	3.298	4/4	NA
Radium-228	N/A	N/A	0	1.81	0.893	4/4	NA
Thorium-227	N/A	N/A	0.041	0.446	0.159	4/4	NA
Thorium-228	N/A	N/A	0.912	4.55	1.946	4/4	NA
Thorium-230	N/A	N/A	2	3.43	2.61	4/4	NA
Thorium-232	N/A	N/A	0.086	0.386	0.229	4/4	NA
Uranium-234	N/A	N/A	1.48	7.74	4.998	4/4	NA
Uranium-238	N/A	N/A	0.956	8.72	5.392	4/4	NA
General chemistry, mg/l							
Alkalinity	1	1	2	152	36.5	10/11	NA
Hardness	N/A	N/A	11	108	42	12/12	NA
Nitrate	0.02	0.02	0.04	1.6	0.614	8/12	NA
Nitrate/Nitrite	0.02	0.02	0.04	1.6	0.597	7/11	NA
pH (units)	N/A	N/A	4.5	9.65	6.213	12/12	NA
Sulfate	N/A	N/A	2.2	35.2	18.342	12/12	NA
Sulfide	0.5	0.5	0.5	4.3	1.833	6/12	NA
Total Dissolved Solids	N/A	N/A	66	876	252.5	16/16	NA
Total Suspended Solids	1	1	1	900	154.167	6/12	NA
Total Phosphorus	0.01	0.01	0.18	15	3.63	9/12	NA
Total Organic Carbon	N/A	N/A	1.3	26.1	9.8	12/12	NA
Total Petroleum Hydrocarbons	1	1	2.6	3.5	2.933	3/41	NA
See notes at end of table							

Table 4-3 (Continued)
Summary Statistics of Detected Analytes/Compounds in Groundwater Samples

Remedial Investigation Report, Operable Unit 1
 North Grinder Landfill
 Naval Training Center
 Orlando, Florida

Parameter	Min. Detection Limit	Max. Detection Limit	Min. De- tected Level	Max. Detected Level	Average Positive Detections	Num Det./ Total No. Samples	Back- ground
<u>Filtered Groundwater</u>							
<u>Inorganics, µg/l</u>							
Aluminum	24.7	24.7	32.6	11,500	1,417.4	29/30	NA
Arsenic	1.5	14.8	14.5	14.5	14.5	1/30	NA
Barium	0.5	3.4	4.6	353	41.575	28/30	NA
Beryllium	0.2	0.2	1.1	5	2.3	4/30	NA
Calcium	15.7	15.7	1,610	94,700	14,061.379	29/30	NA
Chromium	2	9	2.1	19.4	5.433	6/30	NA
Cobalt	3	3	3.1	3.9	3.5	2/30	NA
Copper	1.4	3	1.4	6.4	2.4	10/30	NA
Iron	6.1	6.1	31.2	2,820	763.243	23/30	NA
Lead	1.3	1.3	1.8	6.1	3.367	3/30	NA
Magnesium	28	28	384	4,050	1,685.31	29/30	NA
Manganese	0.5	0.5	0.86	82	10.797	28/30	NA
Mercury	0.04	0.11	0.04	0.06	0.05	4/30	NA
Nickel	11.2	12.7	11.4	11.4	11.4	1/30	NA
Potassium	403	403	540	18,200	3,088.643	28/30	NA
Selenium	0.6	0.6	1	3.9	2.4	4/14	NA
Silver	2.4	2.4	2.7	2.8	2.767	3/30	NA
Sodium	214	214	1,470	38,200	10,649.31	29/30	NA
Thallium	1.9	18.7	1.9	4.6	2.95	6/30	NA
Vanadium	2.9	2.9	3.1	50.2	11.208	12/30	NA
Zinc	1.2	11.3	1.5	30.2	4.742	19/30	NA
<u>Radiological, pCi/l</u>							
Gross Alpha	N/A	N/A	21.3	33.9	28.875	4/4	NA
Gross Beta	N/A	N/A	18.9	86.8	37.975	4/4	NA
Cesium-137	N/A	N/A	-1.29	0.264	-0.829	4/4	NA
Potassium-40	N/A	N/A	-109	65.2	13.625	4/4	NA
Radium-226	N/A	N/A	0	4.61	3.14	4/4	NA
Radium-228	N/A	N/A	0	2.03	1.078	4/4	NA
Thorium-227	N/A	N/A	0.036	0.504	0.169	4/4	NA
Thorium-228	N/A	N/A	1.14	4.82	2.08	4/4	NA
See notes at end of table							

Table 4-3 (Continued)
Summary Statistics of Detected Analytes/Compounds in Groundwater Samples

Remedial Investigation Report, Operable Unit 1
 North Grinder Landfill
 Naval Training Center
 Orlando, Florida

Parameter	Min. Detection Limit	Max. Detection Limit	Min. De- tected Level	Max. Detected Level	Average Positive Detections	Num Det./ Total No. Samples	Back- ground
<u>Filtered Groundwater (Cont.)</u>							
Radiological, pCi/l							
Thorium-230	N/A	N/A	2.35	4.5	3.202	4/4	NA
Thorium-232	N/A	N/A	0.081	0.291	0.225	4/4	NA
Uranium-234	N/A	N/A	1.34	9.08	5.85	4/4	NA
Uranium-238	N/A	N/A	1.23	9	5.665	4/4	NA
Notes: Num.Det/Tot.Sample = Number of detects / total number analyzed. NA = Not applicable. -- =							

Table 4-4
Summary of Population Comparisons on OU 1 Versus Background Groundwater
Analytical Results

Remedial Investigation Report, Operable Unit 1
 North Grinder Landfill
 Naval Training Center
 Orlando, Florida

Parameter	Population statistical summary
Potassium	OU 1 population significantly higher
Gross beta	OU 1 population significantly higher than background and FDEP's St. Johns' Water Management District shallow aquifer database
Vanadium	Background population significantly higher
Acetone, bis(2-Ethylhexyl)phthalate	Different populations but comparison largely driven by detection limit differences; detections appear to be field and/or laboratory artifacts; not considered site-related.
Cadmium, Chloromethane, Methylene Chloride	Different populations but comparison largely driven by detection limit differences. Cadmium has one detection in the OU 1 data set. Likewise, chloromethane and methylene chloride were detected in one DPT sample; not considered site-related.
Carbon disulfide	Different populations but comparison largely driven by detection limit differences; detections primarily in confirmatory DPT samples at levels below CRQLs. May not be site-related as compound can naturally occur at low levels from degradation of high carbonaceous materials (peat).
Chlorobenzene	Different populations but comparison largely driven by detection limit differences; all detections are below CRQLs; not considered significant.
Selenium	Different populations but comparison largely driven by detection limit differences; detections are lower than the two maximum detections in the background population; within ranges of background concentrations and not considered site-related.
<p>Notes:</p> <p>See Appendix I-5 for details on these population comparisons. "Detection limit differences" means that numerous data points in both data sets are below detection limits and therefore the population differences may be attributed primarily to the differences in detection limits and not the few actual detections.</p> <p>CRQL = Contract Required Quantitation Limits DPT = direct push technology OU 1 sample data set for volatile organics included Level III data from DPT sampling program confirmatory samples.</p>	

surficial aquifer, a comparison between OU 1 and background data may not be useful, as the background data set includes only shallow monitoring wells. Nevertheless, statistical analysis of OU 1 groundwater inorganic data and the background data set indicate no population differences for most inorganics, except for cadmium, potassium, selenium, and vanadium. Cadmium and selenium, however, are not considered site-related (Table 4-4). The difference in potassium populations can be accounted for by grout intrusion in deep well OLD-U1-27, the sample which exhibited the only outside value. Initial purged water from this well has also consistently tested high in pH (ranging from 8.98 to 11.34).

Most of the inorganic concentrations above background levels are below FDEP guidelines or Federal MCLs, with the exception of beryllium, vanadium, and manganese, which were detected at 7.1 $\mu\text{g}/\ell$, 104 $\mu\text{g}/\ell$, and 116 $\mu\text{g}/\ell$, respectively, in a sample from a deep well (OLD-U1-03), and thallium at 4.6 $\mu\text{g}/\ell$ in a sample from an intermediate well (OLD-U1-08). These concentrations exceed their FDEP guidelines of 4 $\mu\text{g}/\ell$, 49 $\mu\text{g}/\ell$, 50 $\mu\text{g}/\ell$, and 2 $\mu\text{g}/\ell$, respectively. Background values for aluminum and iron, which were exceeded by one or both inorganics in samples from wells OLD-U1-03, -06, -17, -23, -26, and -27, are higher than FDEP guidelines (Figure 4-2). As will be discussed in section 4.3.3.8, there appears to be a relationship between certain inorganics (especially vanadium) detected in OU 1 groundwater samples and elevated radiological parameters.

4.3.3.6 Radiological Parameters Elevated gross alpha (above MCL of 15 pCi/ ℓ) was detected in groundwater samples from four monitoring wells: deep well OLD-U1-03, intermediate well OLD-U1-14, intermediate well OLD-U1-26 and deep well OLD-U1-27 (Table 4-3 and Figure 4-2). The background screening concentration for gross alpha is 13.0 pCi/ ℓ . Detected gross alpha in the sample from deep well OLD-U1-06 exceeded the background concentration, but not the MCL. Elevated gross beta (above background level of 9.5 pCi/ ℓ) was also detected in these same five samples, and in samples from deep wells OLD-U1-12 and -15, and shallow well OLD-U1-07. Gross beta was 10 times greater than background at well OLD-U1-14 (102 pCi/ ℓ). Background concentrations for both gross alpha and beta are from shallow wells only, and may not represent background concentrations in the basal zone of the surficial aquifer. These elevated levels were confirmed in four wells by resampling and analysis, which included specific radionuclides to establish major alpha and beta emitters. The specific radionuclides contributing to the

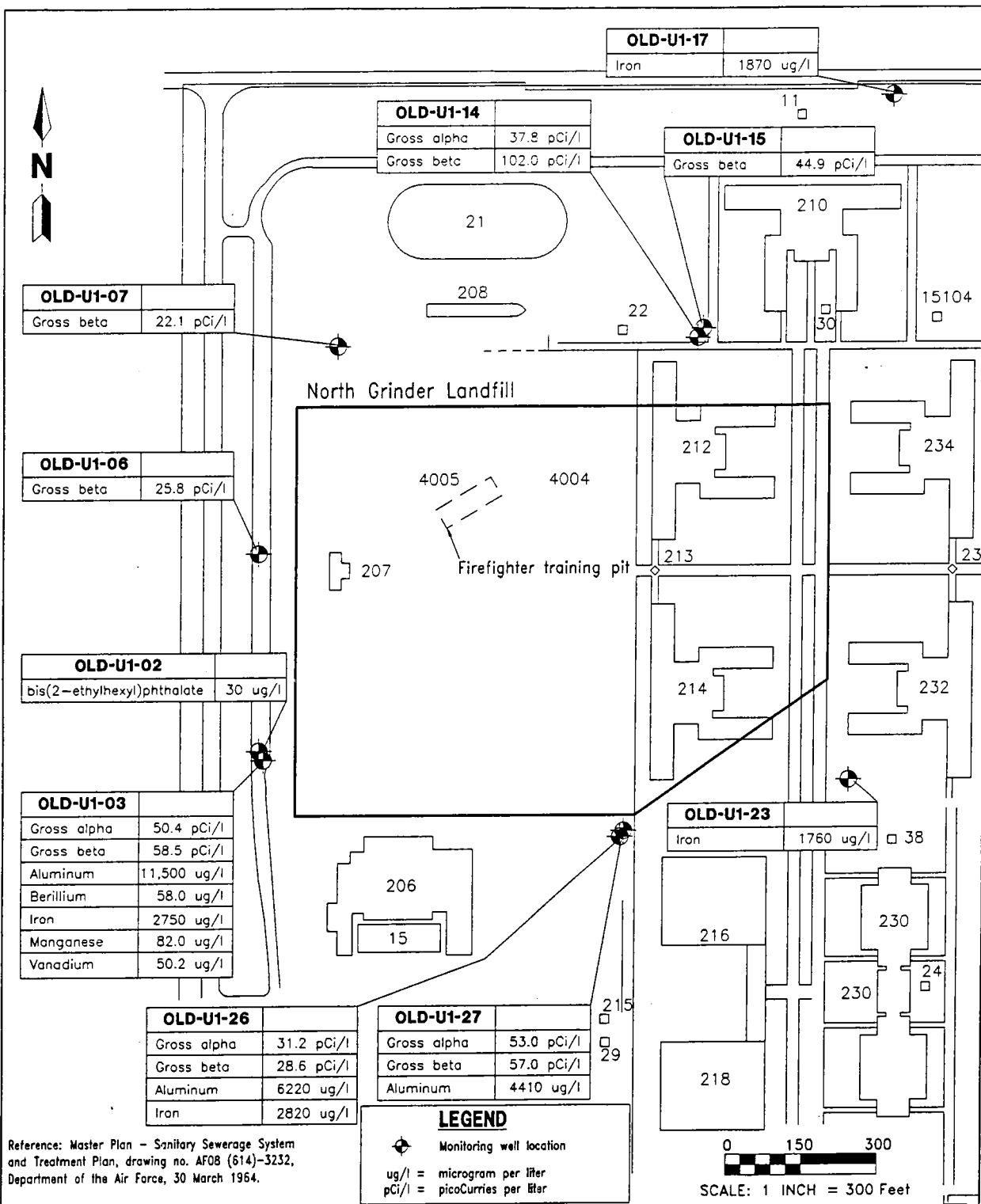


FIGURE 4-2
LOCATION OF ANALYTES IN GROUNDWATER
EXCEEDING MAXIMUM CONTAMINANT LEVELS (MCLs)



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elevated radioactivity in OU 1 groundwater is discussed in section 4.3.3.8 below.

4.3.3.7 Bacteriological Indicators Nine wells were resampled for parameters indicative of anaerobic microbial activity to test the hypothesis that this activity is causing mobilization of naturally occurring radionuclides. These parameters included oxidation-reduction potential (Eh), dissolved oxygen (DO), methane (CH₄), and percent volatile suspended solids (VSS) out of total suspended solids (TSS). Two well clusters, one upgradient and one downgradient, each with an intermediate or deep well screened in groundwater having elevated gross alpha and beta, were included to identify differences in the aquifer with depth. Four analyses (pH, conductivity, Eh, and DO) were performed in the field at all nine wells. Samples for CH₄, TSS, and VSS analysis were only collected from the three wells from which previous samples had the highest gross alpha and beta. The analytical results are summarized in Table 4-5, which includes the previous gross alpha and beta, total dissolved solids (TDS), and total phosphorus results for comparison.

4.3.3.8 Interpretation of Groundwater Data Contaminants detected in the groundwater that exceed background and/or regulatory standards consisted of gross radioactivity and some inorganics. Relative to analytical results of samples from both background and downgradient monitoring wells, gross alpha and gross beta are elevated in the groundwater in the immediate vicinity of the landfill, at depths that are within the Hawthorn Group phosphatic sands above the upper clay layer (OLD-MW-3, OLD-MW-6, OLD-MW-14, OLD-U1-15, OLD-MW-26, and OLD-MW-27). Elevated gross alpha was not detected in samples from any shallow wells, nor from any wells downgradient and outside the immediate vicinity of the landfill. The same is true for gross beta except for one shallow well, OLD-U1-07.

Monitoring wells screened in groundwater with elevated gross alpha and beta were resampled for specific radionuclides to identify radioactive constituents. Specific radionuclides selected for analysis were based on most probable sources (radium paint and natural sources), and included major contributors in the uranium-238 series, potassium-40, and cesium-137.

Table 4-5
General Parameters as Bacteriological Indicators in Groundwater

Remedial Investigation Report, Operable Unit 1
North Grinder Landfill
Naval Training Center
Orlando, Florida

Parameters	Shallow		Intermediate			Deep			
	OLD-U1-01	OLD-U1-13	OLD-U1-02	OLD-U1-14	OLD-U1-26	OLD-U1-03	OLD-U1-06	OLD-U1-15	OLD-U1-27
pH, units	5.44	5.20	4.44	5.10	5.95	5.53	4.99	5.02	6.25
Cond, μ mhos/cm	155	102	60	151	110	61	150	160	120
Eh, mV	190.3	310.9	101.3	62.7	-39.4	92.9	121.1	-3.2	-30.2
DO, mg/ ℓ	5.1	3.0	4.3	3.3	1.5	5.2	2.2	2.0	1.2
CH ₄ , mg/ ℓ	NA	NA	NA	0.116	NA	0.025	NA	NA	0.079
TSS, mg/ ℓ	NA	NA	NA	3	NA	52.5	NA	NA	101.1
%VSS	NA	NA	NA	33	NA	84	NA	NA	78
TDS, mg/ ℓ	NA	NA	NA	NA	92	NA	NA	NA	876
Total P, mg/ ℓ	NA	NA	NA	NA	3.6	NA	NA	NA	15
Gross alpha, pCi/ ℓ	2.0	<1.0	8.7	37.8	31.2	50.4	14.5	11.6	53
Gross beta, pCi/ ℓ	4.8	3.9	7.4	102	28.6	58.5	25.8	44.9	57

Notes:

Reported concentrations expressed in the following units as indicated: μ mhos/cm = micromhos per centimeter; mV = millivolts; mg/ ℓ = milligram per liter;
pCi/l = picocuries per liter.
Cond. = electrical conductivity
Eh = redox potential
CH₄ = methane gas
TSS = total suspended solids
VSS = volatile suspended solids
TDS = total dissolved solids
P = phosphorus
Monitoring wells OLD-U1-01, -02, -03 are one cluster.
Monitoring wells OLD-U1-13, -14, -15 are one cluster.
TDS and total P values for OLD-U1-26 AND -27 are from the 8/95 sampling event.
Gross alpha and beta values are from the 10/95 sampling event.

Of the radionuclides analyzed, the major contributors to gross alpha include uranium-238 and -234, thorium-230 and -228, and radium-226. These alpha emitters accounted for 25 to 55 percent of gross alpha. There may also be some contribution from radon-222 and polonium-210, which are also in the uranium-238 series, but were not analyzed.

The major contributors to gross beta include potassium-40 and radium-228. These beta emitters only accounted for 13 to 17 percent of gross beta, except in one sample, where they accounted for 99 percent. The potassium-40 values are suspect because there is a high uncertainty associated with a gamma scan analysis of this radioisotope. Therefore, potassium-40 may be contributing more to gross beta than is indicated. There appears to be some contribution also from uranium-238 daughters not scanned, such as thorium-234, lead-214, bismuth-214, and lead-210. These daughters were observed in the gamma spectra raw data, but were not quantified. The beta emission from the alpha emitters was also not taken into account.

Potential Sources. Because OU 1 is a military landfill, and all wastes deposited in the landfill may not be documented, several potential radioactive sources must be considered. The hypothesis must not only explain the source of the radionuclides detected, but must also provide reasonable clues as to what radionuclides are contributing most of the gross alpha and beta activity not accounted for. Possible sources include radium paint, medical wastes, and/or nuclear research wastes deposited in the landfill, upgradient contamination, and mobilization of naturally occurring radionuclides associated with the phosphates in the Hawthorn Group deposits. Medical waste is the only documented waste in the landfill with potential radioactivity. The radionuclides associated with each source are given in Table 4-6.

The radioisotope in radium paint is predominantly radium-226. The half-life of radium-226 is approximately 1600 years, yet it is not the parent to all the radionuclides detected, as would be expected if radium paint was the source. In the presence of the uranium isotopes, radium-226 can be explained by uranium-238 decay. For two of the four samples with elevated gross alpha, the radium-226 concentration was less than half of uranium-238, and only slightly exceeded uranium-238 in the one sample and was not detected in the other.

Table 4-6
Expected Radionuclides for Different Sources

Remedial Investigation Report, Operable Unit 1
North Grinder Landfill
Naval Training Center
Orlando, Florida

Source	Radionuclides	
	Major Alpha Emitters	Major Beta Emitters
Naturally Occurring	uranium series: uranium-238, -234, thorium-230, radium-226, radon-222, polonium-210 thorium series: thorium-232, -228, radium-224	uranium series: thorium-234, lead-214, bismuth-214, lead-210, bismuth-210 thorium series: radium-228, lead-212 non-series: potassium-40, rubidium-87, lanthanum-138, cerium-142
Radium Paint	radium-226	
Medical	none	mercury-203, gold-198, iodine-131, sulfur-35, phosphorus-32
Nuclear Research	plutonium-239, uranium-235	cesium-137, cesium-134, strontium-90, tritium

The predominant radioisotopes used in medical research and treatment include phosphorus-32, sulfur-35, iodine-131, gold-198, and mercury-203, all of which have half-lives measured in days. Because these radioisotopes are not produced by radioactive decay of parent radioisotopes with long half-lives, even if they were constituents of medical waste deposited in the landfill, they would have decayed to their stable forms long ago.

Radionuclides from nuclear research, such as plutonium-239, uranium-235, strontium-90, or tritium, were not considered likely contributors to gross alpha and beta because there was no historic evidence that nuclear research was ever conducted at this installation. However, the groundwater was analyzed for cesium-137 (30.17-year half-life), a daughter product from nuclear waste, and it was not detected.

The hypothesis that the radionuclides detected in the basal zone of the surficial aquifer originates from radioactive material buried in the landfill is contradicted by the lack of elevated gross alpha and beta at the top of the surficial aquifer. The one exception to this occurs at shallow monitoring well OLD-U1-07, where gross beta alone is approximately double background (22.1 pCi/l

vs. 9.5 pCi/l). However, this well is sidegradient of the landfill and gross beta is not elevated in the intermediate well of the same cluster.

The absence of elevated gross alpha and beta further downgradient from the immediate vicinity of the landfill reduces the likelihood of an upgradient source, because it is not probable that the leading edge of a plume that originated upgradient occurs only at the fringes of the landfill.

There is significant evidence, however, that supports the hypothesis that naturally occurring radionuclides associated with phosphates of the Hawthorn Group are being mobilized by anaerobic microbial activity at that depth. Of the radionuclides scanned, the significant contributions are from members of the naturally occurring uranium-238 series and potassium-40, which suggests that the remaining contributors are likely naturally occurring radionuclides as well.

Probable Source. The analytical data indicated a trend, such that the samples with high gross alpha and beta also showed increases in physical parameters such as pH, alkalinity, turbidity, TDS, and TOC, and in inorganics such as aluminum, barium, beryllium, chromium, vanadium, and phosphorus (discussed below). This correlation cannot be explained by a cause and effect relationship, but can be explained by a third agent causing all these parameters to increase together.

Uranium is an important trace constituent in marine phosphorite deposits. It co-precipitates with fluorapatite ($\text{Ca}_5\text{F}[\text{PO}_4]$, the predominant mineral) in a reducing environment. Uranium is incorporated both within the crystal lattice of the phosphate mineral and as a sorbed or chemically-complexed phase on clay minerals and organics (Upchurch, et al., 1991). Both radium and thorium in the Hawthorn phosphates most likely originate from radioactive decay of uranium-238. Radium forms strong bonds with sulfate and carbonate, and co-precipitates with barium sulfate (Upchurch, et al., 1991). Radium can substitute for calcium in calcium carbonates. Thorium is rare in marine sediments, but does occur in monazite (a rare earth phosphate). Radium-228 is a decay product in the thorium-232 series. The highest total gross alpha and beta was detected in the sample from monitoring well OLD-U1-14, which is screened through a 2-foot zone observed to have thin phosphorite sand layers (greater than 50 percent phosphate grains).

Leachate generated from landfilled material is known to naturally increase the bacterial activity and density in the groundwater underneath a landfill. At OU 1, there is a significant downward hydraulic head differential between the upper and lower zones of the surficial aquifer along the upgradient (west and south) sides of the landfill. This steeply downward moving groundwater under the landfill has probably caused organic compounds to be carried down to the bottom of the surficial aquifer. Initially, the indigenous bacteria would consume the degradable organics supplied from the downward migrating leachate, thus causing the bacteria density to increase and the redox condition to decrease. Under the reducing conditions created by the microorganisms, other minerals present in this zone are reduced, and the cations and radioisotopes are released into solution. The higher TOC (relative to more shallow locations) indicates an increase in available carbon. Carbon dioxide, and under strongly reducing conditions, methane are produced by metabolically active microorganisms. The production of carbon dioxide may result in a moderate increase in alkalinity and possibly pH. Downgradient of the landfill, where the leachate is diluted and there is less available carbon, the anaerobic microbial activity is minimal, and the concentrations of radionuclides are consistent with background levels.

This hypothesis was tested by resampling selected monitoring wells for parameters (pH, Eh, DO, CH₄, and percent VSS) that would indicate anaerobic microbial activity in the basal zone of the surficial aquifer. The data supports a general trend of Eh and DO decreasing with depth, especially where gross alpha and beta are elevated (OLD-U1-26 AND -27). The Eh and DO at deep well OLD-U1-03 do not correlate as well with the elevated gross alpha and beta. This may be due to the constant supply of oxygenated groundwater at this location, where the downward hydraulic differential is greatest (13 feet), counteracting the reducing activities of the anaerobic bacteria. The samples from the three monitoring wells where gross alpha and beta were highest were also analyzed for CH₄, TSS, and VSS. All three samples indicate the presence of dissolved CH₄ (0.025 to 0.116 mg/l) and an increase in organic suspended material with depth (78 and 84 percent VSS in the deep wells), which would be indicative of available carbon and biomass. However, it appears that total dissolved solids and volatile dissolved solids would be more indicative of the percent biomass (see Table 4-5). According to Qasim and Chiang (1994), the CH₄, Eh, and pH data at OU 1 is indicative of a landfill beginning the second stage of anaerobic decomposition, when the

population of methane-producing bacteria increases, the pH approaches neutral, and the Eh reaches the lowest values.

There appears to be a direct relationship between gross alpha and beta and certain inorganics. This relationship is most obvious between gross alpha and aluminum, barium, beryllium, chromium, and vanadium, as can be deduced from the graphs in Appendix I-6. The regression coefficients for gross alpha and these inorganics are 0.83, 0.75, 0.85, 0.83, and 0.86, respectively. Because of the high correlation between gross alpha and vanadium, the radionuclides are believed to be originating from the phosphates and vanadates (PO_4 and VO_4 commonly substitute for each other) in the Hawthorn Group sediments. Weathered fluorapatite (the "leached zone") produces aluminum phosphates, the reduction of which may account for the increased aluminum. Beryllium can substitute for calcium in fluorapatite. The increase in barium and chromium indicates that barium sulfate and chromates may be present in the Hawthorn sediments.

The graphs also show that the inorganics are more closely related to gross alpha than to gross beta, which usually exceeds alpha and is more variable. This indicates that while the reduction of the phosphates may explain the gross alpha, this may not account for most of the gross beta; unless lanthanum-138 or cerium-142, naturally occurring isotopes of elements found in a rare earth phosphate (monazite), are contributors. This possibility could explain the high gross beta (102 pCi/l) in the groundwater sample collected from OLD-U1-14, which is screened in a phosphorite sand layer. However, the beta emitters in the uranium-238 series (not analyzed) would be a more likely source at this location, as monazite is not a reported mineral in the Hawthorn Group sediments. Another likely source for the gross beta is naturally occurring potassium-40 or rubidium-87 coming from the reduction of clay particles such as illite (K and/or Ba are elevated in samples from OLD-U1-03, -06, -26, and -27). Yet another possible source for the beta emission is carbon-14 from the leachate created by the decay of wood (yard and construction debris) buried in the landfill.

To gain a better understanding of the degree to which the site's radiological parameters are elevated, the gross alpha and beta measurements obtained from OU 1 were compared with a set of those in FDEP's statewide background groundwater quality database. To compare measurements from similar hydrogeologic environ-

ments, only data from wells screened in the surficial aquifer and located in the St. Johns River Water Management District were used. The Mann-Whitney U test was used to compare populations. The results (Table 4-4, Appendix I-5) indicate that there is no evidence of different populations in terms of gross alpha, but that two different populations are seen in terms of gross beta, with the OU 1 data set being higher. The best explanation for the different beta populations appears to be that OU 1, unlike the other sampling locations in the St. Johns River Water Management District, has a landfill that has affected the groundwater chemistry. Because of the leachate generated by the landfill, either carbon-14 has been elevated by the decaying wood, or the leachate induced-anaerobic microbial activity has elevated potassium-40 by reducing the clay particles.

4.4 SUMMARY OF NATURE AND DISTRIBUTION OF CONTAMINATION. The contaminants at OU 1 that exceed background and/or regulatory limits appear to be limited to PAHs in a small area of surface soil, and elevated radiological contamination in the basal zone of the surficial aquifer in the immediate vicinity of the landfill.

4.4.1 Surface Soil Because the small area of surface soil contamination is adjacent to the old firefighter training pit used by the Army Air Corps/US Air Force, the PAHs are believed to have either originated from wind blown ash from burning objects in the fire pit, or from earth moving activities during development of the parade field and spreading the contaminated soil away from the pit. In either case, the PAH contamination does not appear to be related to the landfilled material, and therefore only pertains to the quality of the landfill cover.

The pesticides, PCB, and inorganics detected in the surface soil are believed to be post-landfill contaminants related to the use of the area as a marching parade field.

4.4.2 Groundwater The radiological contamination in the groundwater appears to be caused indirectly by the landfill leachate (anaerobic microbial activity), as

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opposed to directly by leachate from buried radioactive material in the landfill. This was concluded from the following facts.

- The elevated gross alpha and beta only occur in the immediate vicinity of the landfill and only near the base of the surficial aquifer, where there are phosphorite sands associated with the Hawthorn Group. None of the samples from downgradient wells (shallow to deep) outside the immediate vicinity of the landfill had elevated radiological contamination, nor did the shallow wells in the same clusters where elevated radiological contamination occurs at depth.
- The samples with elevated gross alpha and beta also have elevated inorganics such as Al, Ba, Be, Cr, V, as well as pH, total P, TDS, TOC, and alkalinity (comparing these last five parameters in samples from downgradient well clusters OLD-U1-10 through -12 and OLD-U1-16 through -18 vs well cluster OLD-U1-25 through -27; see Appendix I-3).
- Evidence of anaerobic microbial activity was found in the groundwater where elevated gross alpha and beta occurs, such as higher TOC and TDS, lower Eh and DO, the presence of CH₄ and a significant percent VSS.
- A mechanism for transporting leachate downward is found in the significant downward head differential (3 to 13 feet) between the upper and lower zones of the surficial aquifer on the west and south sides of the landfill. This differential may be caused by the topographic high recharge area located to the south and southwest of the landfill equilibrating with the lower regional water table.
- In an environment with higher anaerobic microbial activity, microbially reduced uranium phosphates and vanadates, radium and barium sulfates, and potassium clay minerals (micas) would put available cations into solution, including the radioactive isotopes attached to these minerals.

5.0 CONTAMINANT FATE AND TRANSPORT

This section evaluates the fate and transport of contaminants detected in the environment at OU 1. Results of the site physical characteristics, source characteristics, and extent of contamination analysis in the previous chapters are combined in this evaluation. The observed extent of contamination, presented in Chapter 4, is used as the basis for assessing the transport pathway's rate of migration and the fate of contaminants over the period between the possible time of release and current conditions. Because of the limited nature of contamination in the surface soil and groundwater at OU 1 and the apparent lack of a discernable plume of contamination outside the landfill boundaries, no detailed analytical or numerical models were developed. Rather, this discussion relies primarily on a simplistic model utilizing the chemical characteristics of identified contaminants and interpretation of existing migration patterns.

5.1 POTENTIAL ROUTES OF MIGRATION. The leaching of contaminants from the surface soil into surrounding soil and groundwater is the primary potential migration mechanism for the transport of identified soil contaminants. For groundwater, the primary potential migration mechanism is groundwater flow which serves to transport contaminants away from the source areas at OU 1. As discussed previously in Section 3.0, the groundwater flow is generally in a northeast direction. Site contaminants do not appear to be transported outside of the landfill source area at concentrations exceeding levels of concern.

5.2 PERSISTENCE AND FATE OF OU 1 CONTAMINANTS. The persistence and fate of PAHs detected in the surface soil and radionuclides detected in the basal zone of the surficial aquifer are discussed in this section.

5.2.1 SVOCs Semivolatile organics detected in the surface soil (landfill cover) that are considered to be a concern (exceed SCGs) at OU 1 are Benzo(a)-pyrene, and Dibenz(a,h)anthracene. These SVOCs have low water solubility and high sorption to soil or organic matter, which inhibit leaching or volatilization, and therefore are unlikely to migrate from their original location. The persistence

is therefore strong, with mobilization and migration being minimal. As long as the asphalt pavement continues to cover the area where the PAH concentration is highest, the immobilization of the PAHs is not expected to change. None of the PAHs detected in the soil were found in the groundwater downgradient of the surface soil contamination (monitoring wells OLD-U1-13 through -15 and OLD-U1-19 through -21). Therefore, the elevated PAHs are not expected to affect the quality of the landfill cover.

5.2.2 Radiological Compounds Elevated (above background or MCL) gross alpha and/or beta were detected in groundwater samples from intermediate to deep monitoring wells located along the perimeter of the landfill (OLD-U1-03, -06, -14, -15, -26, and -27). One shallow monitoring well (OLD-U1-07) also had elevated gross beta alone. Not all potential contributing radionuclides were tested, but the specific radionuclides known to significantly contribute to gross alpha and beta are uranium-238 and -234, thorium-230 and -228, radium-226 and -228, and potassium-40. When the elevated radioactive constituents are correlated with the hydrogeology and other groundwater chemistry data, one may reasonably conclude that the radiological contamination is due to mobilization of naturally occurring radionuclides rather than to buried radioactive material in the landfill. The natural uranium-238 series radioisotopes, which are known to be associated with the phosphates of the Hawthorn deposits, appear to be mobilized in the vicinity of the landfill and not further downgradient.

This mobilization is best explained by a change in groundwater chemistry due to anaerobic bacteria enhancement by the landfill leachate. The organic acids in the leachate, being carried down by a steep downward hydraulic head differential in the southwest corner of the landfill, enhanced activity and density of anaerobic bacteria in the basal zone of the surficial aquifer. As long as the landfill produces leachate, and the anaerobic bacteria have the phosphates, vanadates, sulfates, and carbonates present as nutrients, the radionuclides associated with these compounds will continue to be mobilized into the aquifer. As the landfill ages and the available leachate (oxygen) decreases, the population of methane producing anaerobic bacteria will increase, but as pH becomes neutral, conductivity falls and the solubility of inorganics will decrease (Qasim and Chiang, 1994). Eventually, as fresh groundwater moves through, the groundwater chemistry below the landfill will return to background.

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Further downgradient from the landfill, the leachate is diluted and the anaerobic bacteria density is normal. As the low Eh groundwater mixes with oxygenated groundwater, and uranyl complexes form, which are readily sorbed on colloidal particles such as organics, ferric hydroxides, and clays, and radionuclides are no longer detected at concentrations above MCLs. It appears that natural processes controlling groundwater Eh are preventing downgradient migration of the mobilized radionuclides. Therefore, downgradient surface water bodies, such as Lake Spier and Lake Berry, are apparently not threatened by elevated radionuclides at the landfill.

6.0 HUMAN HEALTH RISK ASSESSMENT

6.1 HUMAN HEALTH RISK ASSESSMENT. A human health risk assessment (HHRA) has been conducted as part of the Remedial Investigation (RI) completed for NTC, Orlando Operable Unit Number 1 (OU 1). The purpose of the HHRA is to characterize the human health risks associated with potential exposures to site-related contaminants in environmental media present at and migrating from the former North Grinder Landfill.

Chapter 6.1, Human Health Risk Assessment (HHRA), includes the characterization of the risks associated with potential exposures to site-related contaminants detected at OU 1 for human health receptors. This risk assessment is organized as follows: Section 6.1 includes seven subsections: Subsection 6.1.1 Data evaluation; Subsection 6.1.2 Selection of human health chemicals of potential concern (HHCCPC); Subsection 6.1.3 Exposure assessment; Subsection 6.1.4 Toxicity assessment, and Subsection 6.1.5 Risk characterization, including uncertainty analysis; Subsection 6.1.6 is the human health risk assessment summary; and following the risk assessment is a presentation of remedial goal options, Subsection 6.1.7. Appendices J-1 through J-9 provide documentation of various aspects of this risk assessment.

(The remainder of this section has been omitted because it is considered nonessential for this submittal).

6.1.1 Data Evaluation (This Subsection has been omitted because it is considered nonessential for this submittal).

6.1.2 Selection of Chemicals of Potential Concern (This Subsection has been omitted because it is considered nonessential for this submittal).

6.1.3 Exposure Assessment The exposure assessment is conducted to estimate the pathways by which humans are potentially exposed, the magnitude of actual and/or potential human exposure, and the frequency and duration of exposure. This process is performed for both current and future site land uses. This process involves several steps:

Table 6-3
Groundwater Samples Considered in Risk Assessment

Remedial Investigation, Operable Unit One
 Naval Training Center Orlando
 Orlando, Florida

Shallow Groundwater Samples	Medium Groundwater Samples	Deep groundwater samples
U1G00101	U1G00201	U1G00301
U1G00401	U1G00501	U1G00601
U1G00701	U1G00801	U1G00901
U1G01001	U1G01101	U1G01201
U1G01001D	U1G01401	U1G01501
U1G01301	U1G01701	U1G01801
U1G01601	U1G01701D	U1G02101
U1G01901	U1G02001	U1G02401
U1G02201	U1G02301	U1G02701
U1G02501	U1G02601	U1G02701D
ORG00103	U1G01403	U1G00303
ORG00103D	U1G02603	U1G02703

- characterization of the exposure setting in terms of physical characteristics and the populations that may potentially be exposed to site-related chemicals;
- identification of potential exposure pathways and receptors; and
- quantification of exposure for each population in terms of the amount of chemical either ingested, inhaled, or absorbed through the skin from all complete exposure pathways.

6.1.3.1 Characterization of Exposure Setting In the characterization of the exposure setting for an HHRA, the physical setting and demographics near the waste site are identified. The physical setting is characterized in terms of the following attributes: climate, meteorology, geology, vegetation, soil type, groundwater, and surface water. This information is gathered from previous investigations and is presented elsewhere in this RI. The information generated from the evaluation of the physical setting aids in defining the physical mechanisms that control or influence how people could be exposed at a waste site and provides information on the potential migration of contaminants.

Demographics are also characterized and identified for (1) the populations residing or working near the waste site; (2) the activity patterns of residents and/or workers; and (3) if any exist, the locations of potentially sensitive subgroups. Sources of this information include (1) site visits, (2) previous investigations, (3) information generated during the RI, (4) maps, (5) aerial and standard photographs, and (6) Navy personnel interviews. Key to this activity is determining current and foreseeable future land use of the waste site and surrounding areas (e.g., residential, commercial and industrial, or recreational). Future land use of OU 1 will be controlled in part by institutional controls associated with the presumptive remedy which is described earlier in this report.

6.1.3.2 Identification of Exposure Pathways and Receptors The purpose of this step in the exposure assessment is the identification of all relevant exposure pathways through which specific populations may be exposed, under current and future land use, to contaminants at the site. An exposure pathway consists of four necessary elements: a source or mechanism of chemical release, a transport

or retention medium, a point of human contact, and a route of exposure at the point of contact (USEPA, 1989a). Exposure pathways that have these elements are considered complete pathways. Only complete exposure pathways are evaluated in the HHRA.

In most cases, the source of contamination is either in the soil, or soil is the initial receiving medium. There are several mechanisms for migration of contaminants from soil. Contaminants may accumulate in plants and animals that are in contact with soil or are in food chains that include biota in direct contact with soil. Mechanisms for migration into air include volatilization (primarily VOCs) and wind erosion of contaminated soil (all types of contaminants). Overland flow of water can result in migration of contaminants to surface water and sediment and in relocation to other surface soil (all types of contaminants). Infiltration can result in migration into subsurface soil and into groundwater (soluble contaminants). Contaminants can be transported in groundwater (primarily soluble VOCs, SVOCs, and inorganics) and may potentially also discharge to surface water. Analytes can also be transferred to sediment (generally insoluble forms of inorganics and relatively insoluble SVOCs and pesticides) and to fish (primarily non-polar organics and some inorganics that tend to accumulate in tissue) and other biota.

Human receptors are identified based on the current and potential future land uses. Receptors commonly include future residents (when reasonably expected) and excavation workers, and current site workers and trespassers. Exposure scenarios are constructed to evaluate each receptor (Subsection 6.1.3.3). Medium-specific receptors and exposure scenarios have been identified for current and future land use as described below. This information is also summarized in Table 6-4 and Figure 6-1.

Surface Soil. The evaluation of risks associated with surface soil exposures is conducted here to determine if a cap is required as part of a presumptive remedy for municipal landfills. Under a presumptive remedy scenario, it is not necessary to conduct a risk assessment for potential exposure to soils which will be covered by a cap. If, however, risks associated with surface soil exposures are insignificant and there are no concerns about leaching of contaminants from the landfill into groundwater, a cap may not be necessary as part of the presumptive

Table 6-4
Summary of Potential Human Exposure Pathways

Remedial Investigation Report, Operable Unit 1
North Grinder Landfill
Naval Training Center
Orlando, Florida

Medium of Exposure	Route of Exposure	Potentially Exposed Population	Selected for Evaluation?	Reason for Selection or Exclusion
<u>Current Land Use</u>				
Surface Soil	Dermal contact with soil, ingestion of soil, and inhalation of fugitive dust.	Resident (child and adult) Trespasser (adolescent and adult) Occupational worker (adult) Site maintenance worker (adult) Excavation worker (adult)	No Yes No No No	No humans currently reside at the North Grinder Landfill. Adolescents and adults may be exposed to contaminants in the surface soil while trespassing. Most of the North Grinder Landfill Area is paved; therefore, it is unlikely that occupational and site maintenance workers will be exposed to contaminants in surface soil. No excavation work is anticipated under current land use.
Subsurface Soil	Dermal contact with soil, ingestion of soil, and inhalation of fugitive dust.	Excavation worker (adult)	No	No subsurface soil has been sampled.
Groundwater:	Ingestion of groundwater as drinking water and inhalation of volatiles while showering.	Resident (adult)	No	There are no current exposures to groundwater.
Surface Water	Dermal contact with surface water and ingestion of surface water while wading.	Resident (child and adult) Trespasser (adolescent and adult)	No No	No surface water present.
Sediment	Dermal contact with sediment and ingestion of sediment.	Resident (child and adult) Trespasser (adolescent and adult)	No No	No sediment present.
<u>Future Land Use</u>				
Surface Soil	Dermal contact with soil, ingestion of soil, and inhalation of fugitive dust.	Resident (child and adult) Recreational user (adolescent and adult) Occupational worker (adult) Site maintenance worker (adult) Excavation worker (adult)	No Yes Yes Yes Yes	The North Grinder Landfill will not be developed for residential use. If the North Grinder Landfill area were developed for industrial use, occupational and site maintenance workers may be exposed to contaminants in surface soil. Excavation workers could also be exposed to contaminants in surface soil; if the area were converted to recreational use, adolescents and adults could be exposed.

Table 6-4 (Continued)
Summary of Potential Human Exposure Pathways

Remedial Investigation Report, Operable Unit 1
North Grinder Landfill
Naval Training Center
Orlando, Florida

Medium of Exposure	Route of Exposure	Potentially Exposed Population	Selected for Evaluation?	Reason for Selection or Exclusion
Future Land Use (Cont)				
Subsurface Soil	Dermal contact with soil, ingestion of soil, and inhalation of fugitive dust.	Excavation worker (adult)	No	No subsurface soil was sampled.
Groundwater:	Ingestion of groundwater as drinking water and inhalation of volatiles while showering	Resident (adult)	No	The North Grinder Landfill will not be developed for residential use. Wells for any use will not be installed in the area. There is no migration of contamination via groundwater.
Surface Water	Dermal contact with surface water and ingestion of surface water while wading.	Resident (child and adult) Trespasser (adolescent and adult)	No No	No surface water present.
Sediment	Dermal contact with sediment and ingestion of sediment.	Resident (child and adult) Trespasser (adolescent and adult)	No No	No sediment present.

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Figure 6-1 Complete Exposure Pathways for Human Receptors, the North Grinder Landfill

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remedy. In some cases where a presumptive remedy is being considered, risks associated with all media may be insignificant and no remedy may be required. The surface soil risk evaluation shown here was conducted to provide information concerning the need for a cap.

The North Grinder Landfill area is currently used as a parade ground. Much of the area of the former landfill is covered with asphalt pavement. Although permission is required to obtain access to NTC, Orlando, the North Grinder Landfill and the surrounding area are accessible to Navy personnel and their adult and child dependents. Currently, adult and adolescent trespassers could be exposed to contaminants in surface soil outside the boundaries of the paved area; therefore, exposure of these receptors (ingestion of and direct contact with surface soil and inhalation of particulates from surface soil) is evaluated in the HHRA. Much of the North Grinder Landfill area is paved; therefore, it is unlikely that occupational and site maintenance workers are currently exposed to contaminants in surface soil.

No humans currently reside at the North Grinder Landfill. A deed restriction will prevent conversion of the North Grinder Landfill area to residential use. Therefore, exposure of theoretical future residents to contaminants in surface soil is not evaluated in the HHRA.

If the North Grinder Landfill is developed for industrial use in the future, occupational workers and excavation workers could be exposed to contaminants in surface soil. Therefore, potential exposure of these receptors to contaminants in surface soil is evaluated in the HHRA. In addition, should the area be converted to recreational use (such as ball fields), older child and adult receptors could be exposed to contaminants on surface soil (or existing landfill cover if the pavement were removed and not replaced. Therefore, potential exposures of these receptors is evaluated in the HHRA.

Groundwater. Currently, humans do not reside at the North Grinder Landfill and groundwater is not used for any potable or non-potable purpose. The North Grinder Landfill area will not be developed for residential use and a deed restriction will prevent the installation of wells in the North Grinder Landfill area for potable or non-potable use of the groundwater. There is no indication that any

migration of contamination to off-site areas has occurred or is likely to occur in the future. Therefore, there are no complete exposure pathways for groundwater. No further exposure assessment or risk characterization is conducted for groundwater at the North Grinder Landfill.

Surface Water. There is no surface water associated with the north Grinder Landfill.

Sediment. There is no sediment associated with the North Grinder Landfill.

6.1.3.3 Quantification of Exposures Once complete exposure pathways are selected for evaluation (Subsection 6.1.3.2), the final step of the exposure assessment is to quantify exposure (i.e., intake) for each pathway. This quantification process involves developing assumptions regarding exposure conditions and exposure scenarios for each receptor to estimate the total amount of contaminants that a hypothetical receptor may ingest, dermally absorb, or inhale from each exposure pathway. These exposure scenarios are based on several variables, which can be grouped into chemical-, population-, and assessment-related variables.

The ultimate goal of this step, as defined in USEPA guidance, is to identify the combination of these exposure variables or parameters that results in the most intense level of exposure that may "reasonably" be expected to occur under current and future site conditions (USEPA, 1989a). This is performed for every complete exposure pathway selected for evaluation. The resulting exposure scenarios are referred to as the reasonable maximum exposure (RME) for each exposure pathway. More recent USEPA Guidance (USEPA, 1992c) recommends developing two exposure scenarios, an average exposure and a "high end," or RME. This guidance also suggests that other uncertainty analyses, including Monte Carlo analysis, can be useful in putting risk estimates into perspective.

Chemical-Related Variable. The chemical-related variable is the exposure point concentration (EPC), which is the representative concentration at the exposure point. The EPCs are calculated in a manner consistent with USEPA guidance (USEPA, 1989a; 1992c; 1992d). The EPCs are, with the exceptions noted below, the 95 percent upper confidence limit (UCL) on the arithmetic mean of the concentrations in the dataset used to evaluate exposure. The following equation for calculating

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the UCL on the arithmetic mean for a lognormal distribution (USEPA, 1991a; 1992d) is used to calculate all UCLs:

$$UCL = e^{(\bar{x} + 0.5 s^2 + \frac{s H}{\sqrt{n-1}})} \quad (1)$$

where:

UCL = upper confidence limit,
e = constant (base of the natural log, equal to 2.718),
xbar = mean of transformed data,
s = standard deviation of the transformed data,
H = H-statistic (from table published in Gilbert, 1987), and
n = number of samples.

In calculating the 95 percent UCLs, non-detects are assigned a value of one-half the associated reporting limits in the calculation of the arithmetic mean. In cases where there are fewer than four samples or where the UCL is greater than the maximum detected concentration, the maximum detected concentration is identified as the EPC.

EPCs for surface soil were determined as described above. The EPCs for analytes selected as HHCPs for surface soil are presented in Table 6-5.

Population-Related Variables. Population-related variables describe the characteristics of a hypothetical individual receptor within each potentially exposed population. These variables include contact rates, such as exposure frequencies and ingestion rates, and physical characteristics of human bodies,

Table 6-5
Exposure Point Concentrations for Human Health Chemicals of Potential Concern

Remedial Investigation Report, Operable Unit 1
 North Grinder Landfill
 Naval Training Center
 Orlando, Florida

Chemical	Frequency of Detection ¹	Maximum Detected Concentration	95% UCL ²	Exposure Point Concentration ³
Semivolatile Organics ($\mu\text{g}/\text{kg}$)				
Benzo(a)anthracene	3/14	480	224	224
Benzo(a)pyrene	3/14	1,200	340	340
Benzo(b)fluoranthene	2/14	410	217	217
Benzo(k)fluoranthene	3/14	4,000	602	602
Chrysene	3/14	500	240	240
Dibenz(a,h)anthracene	2/14	760	257	257
Indeno(1,2,3-cd)pyrene	3/14	2,300	428	428
Pesticides/PCBs ($\mu\text{g}/\text{kg}$)				
Dieldrin	7/14	175	196	175
gamma-BHC (Lindane)	1/14	1,025	1.4	1,025
Aroclor-1260	6/14	150	78.3	78.3
Inorganics (mg/kg)				
Arsenic	10/14	2.7	2.1	2.1

¹ Frequency of detection is the number of samples in which the analyte was detected divided by the number of samples analyzed.

² The 95 percent UCL is calculated on the arithmetic mean of all samples using one-half the contract-required quantitation limit or contract-required detection limit (CRQL/CRDL) for non-detected concentrations.

³ The exposure point concentration equals the 95 percent UCL unless the maximum detected concentration is less than the 95 percent UCL. If there are nine or less total samples, the maximum detected concentration is the exposure point concentration.

Notes:

% = percent.

UCL = upper confidence limit.

$\mu\text{g}/\text{kg}$ = micrograms per kilogram.

mg/kg = milligrams per kilogram.

PCBs = polychlorinated biphenyls.

such as body weights and surface areas. When applicable, contact rates are selected from USEPA standard default exposure factor guidance (USEPA, 1991a) or USEPA dermal guidance (USEPA, 1992b). If site-specific factors indicate that such parameters are not appropriate, alternative parameters are used based on knowledge of human behavior and the relative accessibility of a site. Parameters describing the physical characteristics of the exposed populations are identified from appropriate USEPA guidance (USEPA, 1989a; 1989b; 1991a), and are presented in Appendix J-4.

Assessment-Related Variable. The assessment-related variable involved in exposure quantification is the averaging time. Averaging time reflects the duration of exposure and depends on the type of effect being evaluated. Exposure intake during a defined interval (e.g., a lifetime) is averaged over the entire period, resulting in an estimate of average daily intake.

There are essentially two types of effects typically evaluated in human health risk assessment: carcinogenic effects and noncarcinogenic effects. According to USEPA guidance, the averaging time for carcinogenic effects is assumed to be a 70-year lifetime (USEPA, 1989a). The averaging times for noncarcinogenic effects are equivalent to the duration of exposure and may vary depending on the nature of exposure. There is a wide range of possible estimates, from a day to a lifetime. However, based on USEPA guidance, exposure duration for noncarcinogenic effects can roughly be categorized into one of three periods: (1) chronic exposures: 7 years to a lifetime; (2) subchronic exposures: 2 weeks to 7 years; and (3) acute exposures: less than 2 weeks (USEPA, 1989a). The length of the exposure period depends on the potentially exposed population and the characteristics of exposure. The averaging times applied to receptors are used in the risk calculations. All exposure scenarios evaluated for noncarcinogenic effects at NTC Orlando are considered chronic or subchronic exposures.

Calculation of Intakes. The equations used to calculate chemical intake are those presented in USEPA guidance (USEPA, 1989a). The general equation for calculating chemical intake is as follows:

$$Intake = \frac{C \times CR \times EF \times ED}{BW \times AT} \quad (2)$$

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where:

Intake = daily chemical intake per unit body weight averaged over the exposure period,
C = concentration of the chemical in the exposure medium,
CR = contact rate for the medium of concern,
EF = exposure frequency,
ED = exposure duration,
BW = body weight of the hypothetically exposed individual,
AT = averaging time (for carcinogens, AT = 70 years for 365 days per year; for noncarcinogens, AT = ED).

The contaminant exposure intakes for the receptors that were evaluated are presented in the risk calculation spreadsheets in Appendix J-5.

Some of the exposure pathways require additional calculations before intake values can be calculated. Brief explanations of the additional calculations required for the inhalation of particulates, inhalation of vapors while showering, and dermal absorption are provided below.

Inhalation of Particulates from Soil. This evaluation is conducted to estimate levels of site contaminants that could occur in ambient air as a result of wind erosion. To estimate atmospheric concentrations of fugitive air contaminants, a three step modeling process is conducted. In the first step, respirable particle-phase emission rates are calculated. In the second step, contaminant emission rates on a unit surface area basis are calculated. In the third step, downwind ambient concentrations are estimated using air dispersion modeling. The three step process is further defined in Appendix J-6.

Dermal Absorption from Soil. Dermal absorption from soil is calculated in accordance with the USEPA Dermal Exposure Assessment: Principles and Applications, Interim Report (USEPA, 1992b). Percutaneous absorption of chemicals detected in soil is chemical and matrix dependent. According to USEPA Region IV guidance (USEPA, 1995a), absorption factors for organics and inorganics are 0.1 percent and 0.01 percent, respectively. A soil adherence factor of 1 milligram of soil per square centimeter of skin (mg/cm²) per event is used in the dermal intake equations (USEPA, 1992b). The equations used to describe dermal absorption from soil are located in Appendix J-7.

Receptor-specific exposure parameters for each exposure scenario are presented in Appendix J-4. The risk calculation spreadsheets in Appendix J-5 to this report also contain the exposure parameters for each exposure scenario.

6.1.4 Toxicity Assessment The purpose of the toxicity assessment is to identify the adverse effects that are associated with exposure to each HHCP and to identify the relationship between the level of exposure and the severity or likelihood of adverse effects. The toxicity assessment evaluates the available evidence on the potential adverse effects associated with exposure to each HHCP. With this information, a relationship between the extent of exposure and the likelihood or severity of adverse human health effects is developed. Two steps are typically associated with toxicity assessment: hazard identification and dose-response assessment.

6.1.4.1 Hazard Identification Hazard identification is the process of determining if exposure to an agent can cause a particular adverse health effect and, more importantly, if that effect will occur in humans. Characterizing the nature and strength of causation is a part of the hazard identification step. For a number of the chemicals at hazardous waste sites, potential toxic effects have already been identified. Consequently, the objectives of the hazard identification in the HHRA are to (1) identify which of the contaminants detected at the site are potential hazards, and (2) summarize their potential toxicity in brief narrative profiles.

6.1.4.2 Dose-Response Assessment A dose-response assessment is conducted to characterize and quantify the relationship between intake, or dose, of an HHCP and the likelihood of a toxic effect, or response. There are two major types of toxic effects evaluated in an HHRA: carcinogenic and noncarcinogenic. Following USEPA guidance for HHRAs (USEPA, 1989a), these two endpoints (cancer and noncancer) are evaluated separately. As a result of the dose-response assessment, identified dose-response values are used to estimate the incidence of adverse effects as a function of human exposure to a chemical.

There are two types of dose-response values: cancer slope factors (CSFs) for carcinogens and reference doses (RfDs) for noncarcinogens. For many compounds, both types of values have been developed by USEPA because many compounds cause

both carcinogenic and noncarcinogenic effects. In addition, because the toxicity and/or carcinogenicity of a compound can depend on the route of exposure (i.e., oral, inhalation, or dermal), unique dose-response values are developed for the oral, dermal, and inhalation exposure routes. The source of the dose-response values are described below. All dose-response values for analytes evaluated in this risk assessment are presented in Appendix J-8.

Cancer Toxicity Values. The CSF is a chemical-specific toxicity value developed by the USEPA Carcinogenic Assessment Group (CAG) based upon the dose of a chemical and the probability of a carcinogenic response. The unit risk, a toxicity value developed by the USEPA, is an estimate of the relationship between the inhaled concentration of a chemical and the probability of a carcinogenic response from the exposure during the lifetime of the individual.

As required by USEPA Region IV guidance (USEPA, 1995a), risks associated with dermal exposures (most commonly for soil and water dermal contact) are evaluated using CSFs that are specific to dermally absorbed doses. Most oral CSFs are based on administered dose rather than the absorbed dose (trichloroethene's CSF is a notable exception). It is, therefore, necessary to adjust toxicity values that are based on administered doses so that they can be used for evaluation of absorbed doses. For dermal exposures, the toxicity values are adjusted as follows:

$$CSF_{adjusted} = \frac{CSF_{oral}}{ABSEFF_{oral}} \quad (3)$$

where $ABSEFF_{oral}$ is the absorption efficiency in the study that is the basis of the oral toxicity value.

If there is no information available on oral absorption efficiency, the conservative default values (USEPA, 1995a) of 80 percent for volatiles, 50 percent for SVOCs, and 20 percent for inorganics are used.

The oral CSF, inhalation CSF and unit risk, dermal CSF, weight of evidence classification, and cancer type observed for each carcinogenic HHCP analyzed in an HHRA are provided in Appendix J-8.

Non-cancer Toxicity Values. The RfD is an estimate (with uncertainty spanning an order of magnitude or more) of a daily intake for the human population, including sensitive subpopulations, that is likely to be without appreciable risk of deleterious effects during a lifetime. Noncarcinogenic risks due to inhalation are estimated by comparing the inhalation concentration to the inhalation correlate of the RfD, the reference concentration (RfC).

As required by USEPA Region IV guidance (USEPA, 1995a), risks associated with dermal exposures (most commonly for soil and water dermal contact) are evaluated using RfDs that are specific to absorbed doses. Most oral RfDs are based on an administered dose rather than on the absorbed dose. It is, therefore, necessary to adjust toxicity values that are based on administered doses so that they can be used for evaluation of absorbed doses. For dermal exposures, we adjust the toxicity values as follows:

$$RfD_{adjusted} = RfD_{oral} \times ABSEFF_{oral} \quad (4)$$

where $ABSEFF_{oral}$ is the absorption efficiency in the study that is the basis of the oral toxicity value.

If there is no information available on oral absorption efficiency, the conservative default values (USEPA, 1995a) of 80 percent for volatiles, 50 percent for SVOCs, and 20 percent for inorganics are used.

Separate sets of RfDs have been developed for several chemicals for evaluating chronic and subchronic exposures. When available, subchronic RfDs are used for evaluating exposures with a duration less than 7 years but more than 2 weeks. Chronic RfDs are used when subchronic values are unavailable and when the exposure duration is greater than 7 years. There are no analogous reference values for evaluating acute exposures, those lasting less than 2 weeks.

The oral RfD, inhalation RfC, dermal RfD, critical study on which the RfD is based, critical effect in the study, any uncertainty and modifying factors applied to the RfD or RfC, and the degree of confidence assigned to the RfD or RfC for each HHCP analyzed in the HHRA is provided in an Appendix J-8.

6.1.4.3 Source of Dose-Response Values The primary source for identifying dose-response values is the USEPA Integrated Risk Information System (IRIS), which is an on-line database containing health risk and USEPA regulatory information about specific chemicals (USEPA, 1996). Health risk information is included on IRIS only after a comprehensive review of chronic toxicity data by work groups composed of USEPA scientists. If no information is found in IRIS, the USEPA Health Effects Assessment Summary Tables (HEAST) (USEPA, 1995d; 1995e) are used as a source of information. If appropriate dose-response values are not located from either of these two sources, other USEPA sources (including past versions of IRIS and HEAST and the documents produced by the USEPA's National center for Environmental Assessment (formerly the Environmental Criteria and Assessment Office) are consulted. If no USEPA dose-response value is identified, surrogate values from structurally similar compounds may be assigned.

Dose-response values for each of the contaminants selected as an HHCP in an HHRA are provided in Appendix J-8. Toxicity profiles for HHCPs are presented in Appendix J-9.

6.1.4.4 Toxicity Equivalency Factors for Carcinogenic PAHs Carcinogenic PAHs are a class of compounds with very similar, complex heterocyclic structures. From this group of compounds, only one, benzo(a)pyrene, has a USEPA published CSF. For the other carcinogenic PAHs, the variable toxicity has been addressed by using Toxicity Equivalency Factors (TEFs) published by USEPA (USEPA, 1993a). The TEFs identify the relative potency of each compound relative to that of benzo(a)pyrene.

The TEFs are not CSFs themselves nor are they used to calculate CSFs for the other PAHs. The TEFs are applied to carcinogenic PAH EPCs to determine the equivalent benzo(a)pyrene concentration. The benzo(a)pyrene equivalent EPC for each carcinogenic PAH is then multiplied by the CSF for benzo(a)pyrene to obtain an estimate of the cancer risk for these compounds. The TEFs are only used in estimating the cancer risk of these compounds and are not used to estimate the noncancer risks. The TEFs for the carcinogenic PAHs are provided in Table 6-6.

6.1.5 Risk Characterization Risk characterization is the final step in the risk assessment process. This step involves the integration of the exposure and toxicity assessments into a qualitative or quantitative expression of potential

human health risks associated with contaminant exposure. Quantitative estimates of both carcinogenic and noncarcinogenic risks are made for each HHCP and each complete exposure pathway identified in the exposure assessment.

Carcinogenic Risks. Carcinogenic risks associated with exposure to individual chemicals are estimated by multiplying the chemical intake for each carcinogen by its CSF. This value is a chemical-specific excess lifetime cancer risk (ELCR) and represents an upper bound of the probability of an individual developing cancer over a lifetime as the result of exposure to a chemical. For each exposure pathway, the chemical-specific risks for all carcinogenic compounds are summed to determine the pathway-specific lifetime cancer risk. The following equations are used to estimate the chemical- and pathway-specific cancer risks:

Table 6-6
Toxicity Equivalency Factors for
Carcinogenic Polycyclic Aromatic Hydrocarbons

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Polynuclear Aromatic Hydrocarbon	Toxicity Equivalency Factors
Benzo(a)pyrene	1
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Chrysene	0.001
Dibenzo(a,h)anthracene	1
Indeno(1,2,3-c,d)pyrene	0.1
Source: U.S. Environmental Protection Agency (USEPA, 1993a).	

Chemical-Specific Excess Lifetime Cancer Risk

$$Risk_i = CDI_i \times CSF_i \quad (5)$$

where:

- $Risk_i$ = unitless probability of an individual developing cancer as the result of exposure to a chemical i ,
 CDI_i = chronic daily intake of chemical i averaged over 70 years and expressed as milligrams per kilogram body weight per day (mg/kg-day), and
 CSF_i = USEPA cancer slope factor for chemical i (mg/kg-day)⁻¹.

Pathway-Specific Incremental Lifetime Cancer Risk

$$Risk_T = \sum Risk_i \quad (6)$$

where

- $Risk_T$ = unitless probability of an individual developing cancer as the result of multiple chemical exposures and
 $Risk_i$ = unitless cancer risk estimate for the i^{th} chemical associated with an exposure pathway

The results from the carcinogenic risk assessment are compared with acceptable risks established by the USEPA. The USEPA guidelines, established in the National Oil and Hazardous Substances Contingency Plan (NCP), indicate that the total lifetime cancer risk due to exposure to the HHCPs at a site, by each complete exposure pathway, should not exceed a range of 1 in 1,000,000 (1×10^{-6}) to 1 in 10,000 (1×10^{-4}) (USEPA, 1990a). For reference, the average cancer burden in the United States in 1993 was 1 in 3 for women and 1 in 2 for men (American Cancer Society, 1994).

Noncarcinogenic Risks. Noncarcinogenic risk estimates are calculated by dividing chemical intake for each compound by the appropriate RfD. The result is called the hazard quotient (HQ). The HQs for individual compounds within an exposure pathway were summed to obtain the hazard index (HI) for that particular pathway.

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The following equations are used to determine the HQs and HIs:

Hazard Quotient

$$HQ_i = \frac{I_i}{RfD_i} \quad (7)$$

where

- HQ_i = hazard quotient of chemical i,
- I_i = intake of chemical i averaged over the exposure period (mg/kg-day), and
- RfD_i = reference dose for chemical i corresponding to the same exposure duration as the intake (mg/kg-day).

Hazard Index

$$HI = \sum HQ_i \quad (8)$$

where

- HI = potential for noncarcinogenic effects from multiple chemical exposures and
- HQ_i = hazard quotient for ith chemical associated with an exposure pathway.

HQ less than 1 indicates that noncarcinogenic toxic effects are not expected to occur due to HHCPD exposure. HIs greater than 1 may be indicative of a possible noncarcinogenic toxic effect but the circumstances must be evaluated on a case-by-case basis (USEPA, 1989a). As the HI increases, so does the likelihood that adverse effects might be associated with exposure. In general, chronic HI values are calculated.

6.1.5.1 Summary Risk estimates are calculated for each OUI are summarized in risk summary tables. The risks are presented by medium for both current and future land uses. The calculations of these estimates are documented in an appendix with all spreadsheets used to complete calculations. Within the risk summary text for each medium and site, the relative confidence in each risk estimate is discussed. The relative significance of risk estimates is evaluated in terms of a comparison with acceptable risk levels established by USEPA.

Both carcinogenic and noncarcinogenic risks were estimated for each HHCPD and each complete exposure pathway selected for evaluation in the exposure assessment.

Risk calculations are documented in the spreadsheets in Appendix J-5. Risk estimates for potential exposures to surface soil under current and future land use scenarios are discussed in Paragraphs 6.1.5.1 and 6.1.5.2, respectively. Tables 6-7 and 6-8 present a summary of the risk estimates.

6.1.5.1 Surface Soil Current Land Use The risk characterization results for current land use surface soil exposure scenarios are shown in Tables J-5.1 through J-5.4 in Appendix J-5 to this report and are summarized in Table 6-7. For the current land use trespasser scenario (which presumes the pavement has been removed), estimated cancer risks are within the USEPA Superfund risk range and the non-cancer hazard index for the child and adult trespasser are both well below one, which is considered an allowable risk level.

For the current land use trespasser scenario, only one compound, dieldrin, is associated with cancer risk greater than 10^{-6} , which is the stated FDEP risk level of concern. The estimated risk of 2×10^{-6} is associated with dermal soil contact (1.2×10^{-6}) and incidental ingestion (6×10^{-7}). The risk estimate is based on the maximum reported concentration of dieldrin ($175 \mu\text{g/kg}$). The mean of detected dieldrin concentrations is $56 \mu\text{g/kg}$, which is below the residential and industrial Cleanup Goals for Florida which are $70 \mu\text{g/kg}$ and $300 \mu\text{g/kg}$ respectively. It should also be noted that the pavement is still in place, so that under current conditions, there really is not any exposure to the surface soils in the immediate area of the former landfill. Therefore, risks associated with surface soil exposure under current land use are within acceptable limits.

6.1.5.2 Surface Soil Future Land Use The risk characterization results for future land use potential surface soil exposure scenarios are shown in Tables J-5.5 through J-5.12 in Appendix J-5 to this report and are summarized in Table 6-7. For potential future land uses, estimated cancer and non-cancer risks for the

Table 6-7
Human Risk Summary for the North Grinder Landfill

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Land Use	Exposure Route	Hazard Index	Excess Lifetime Cancer Risk
<u>Current Land Use</u>			
Surface Soil			
Adolescent trespasser	Incidental ingestion	0.01	1×10^{-6}
	Dermal contact	0.003	4×10^{-7}
	Inhalation of particulates	NC	5×10^{-10}
	Total adolescent trespasser:	0.01	1×10^{-6}
Adult trespasser	Incidental ingestion	0.001	1×10^{-6}
	Dermal contact	0.006	1×10^{-6}
	Inhalation of particulates	NC	2×10^{-8}
	Total adult trespasser:	0.002	2×10^{-6}
	Total trespasser:	NC	3×10^{-6}
<u>Future Land Use</u>			
Surface Soil			
Recreational Child	Incidental ingestion	0.01	1×10^{-6}
	Dermal contact	0.003	4×10^{-7}
	Inhalation of particulates	NC	5×10^{-10}
	Total recreational child :	0.01	1×10^{-6}
Recreational Adult	Incidental ingestion	0.006	1×10^{-6}
	Dermal contact	0.002	6×10^{-7}
	Inhalation of particulates	NC	2×10^{-8}
	Total recreational adult :	0.02	2×10^{-6}
	Total recreational receptor:		3×10^{-6}
Surface Soil			
Site worker	Incidental ingestion	0.01	4×10^{-6}
	Dermal contact	0.005	2×10^{-6}
	Inhalation of particulates	NC	5×10^{-8}
	Total site worker:	0.02	6×10^{-6}

Table 6-7 (Continued)
Human Risk Summary for the North Grinder Landfill

Remedial Investigation Report, Operable Unit 1
 North Grinder Landfill
 Naval Training Center
 Orlando, Florida

Land Use	Exposure Route	Hazard Index	Excess Lifetime Cancer Risk
<u>Future Land Use</u>			
Surface Soil			
Excavation Worker	Incidental ingestion	0.008	9×10^{-6}
	Dermal contact	0.0006	1×10^{-6}
	Inhalation of particulates	NC	7×10^{-6}
	Total excavation worker:	0.009	1×10^{-7}
<p>¹ A hazard index could not be calculated for inhalation exposures because inhalation reference doses were not available for the HHCPs.</p> <p>Notes:</p> <p>NC = not calculated.</p> <p>HHPC = human health chemical of potential concern.</p>			

Table 6-8
Potential Sources of Uncertainty

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Potential Source	Direction of Effect	Justification
Exposure Assessment		
Likelihood of exposure pathways	Overestimate	Actual exposure may not occur
Exposure point concentrations	Unknown	Sampling data are assumed to be representative of the exposures.
Exposure assumptions (e.g., frequency)	Overestimate	Parameters selected are conservative estimates of exposure representing a reasonable maximum exposure.
Degradation of chemicals not considered	Overestimate	Risk estimates are based on recent chemical concentrations. Concentrations tend to decrease over time as a result of degradation for many organics.
Absorption of soil contaminants through the skin	Overestimate	Dermal absorption of chemicals is a function of the length of actual skin contact. Contact may be insufficient to result in the absorption assumed.
Modeled exposure point concentrations	Unknown, probably overestimate.	Models are based on numerous assumptions resulting in conservative exposure point concentrations (EPCs).
Toxicity Assessment		
Extrapolation of animal toxicity data to humans	Unknown, probably overestimate.	Animals and humans differ with respect to adsorption, metabolism, distribution, and excretion of chemicals. The magnitude and direction of the difference varies with each chemical. Animal studies typically involve high-dose exposures, whereas humans are exposed to low doses.
Use of linearized, multi-stage model to derive cancer slope factors	Overestimate	Model assumes a non-threshold, linear at low dose relationship for carcinogens. Many compounds induce cancer by non-genotoxic mechanisms. Model results in 95 percent upper confidence limits of cancer potency. Potency is unlikely to be higher and may be as low as zero.
Lack of oral toxicity values for lead	Underestimate	Dose-response values for lead are not available for exposures to lead in soil or groundwater. Risk from exposure to lead in soil and groundwater is not quantitatively evaluated.
Lack of inhalation toxicity values	Underestimate	Inhalation reference doses (RfDs) and cancer slope factors (CSFs) will not be available for all human health chemicals of potential concern (HHPCs) being evaluated for inhalation exposures (fugitive dust and volatiles while showering). Therefore, risks cannot be quantified and are underestimated.
Risk Characterization		
Summation of risk among chemicals within exposure pathways	Unknown	Little is known about the toxicity of chemical mixtures. In the absence of evidence to the contrary, additivity of risk is assumed.

recreational user, (child and adult), on-site worker and an excavation worker are within acceptable ranges specified for the USEPA Superfund program. Estimated cancer risks for the recreational user, site worker and the excavation worker are 2×10^{-6} , 6×10^{-6} and 1×10^{-7} respectively. Calculated hazard index values for the same receptors are 0.02, 0.02 and 0.009, all well below one, which is considered an allowable level.

For the recreational user, only dieldrin has estimated cancer risk greater than 10^{-6} , which is the FDEP's stated risk level of concern. The estimated risk of 2×10^{-6} is associated with dermal soil contact (1.2×10^{-6}) and incidental ingestion (6×10^{-7}). The risk estimate is based on the maximum reported concentration of dieldrin ($175 \mu\text{g/kg}$). The mean of detected dieldrin concentrations is $56 \mu\text{g/kg}$, which is below the industrial Cleanup Goal for Florida which is $300 \mu\text{g/kg}$. With a deed restriction prohibiting residential use, the dieldrin concentrations would be consistent with the Florida Cleanup Goals.

For the potential future site worker, cancer risks associated with benzo(a)pyrene (1.4×10^{-6}), dibenz(a,h)anthracene (1.1×10^{-6}), dieldrin (1.7×10^{-6}) and arsenic (1.2×10^{-6}) slightly exceed 10^{-6} , which is the stated FDEP risk level of concern. However, the EPCs for each of these four analytes is less than the corresponding Industrial Cleanup Goals for Florida: benzo(a)pyrene EPC of $340 \mu\text{g/kg}$ versus a cleanup goal of $500 \mu\text{g/kg}$; dibenz(a,h)anthracene EPC of $257 \mu\text{g/kg}$ versus a cleanup goal of $500 \mu\text{g/kg}$; dieldrin EPC of $175 \mu\text{g/kg}$ versus a cleanup goal of $300 \mu\text{g/kg}$; and arsenic EPC of 2.1 mg/kg versus a cleanup goal of 3.1 mg/kg . With deed restrictions that prevent residential use of the property, risks meet the USEPA risk limits and site concentrations are consistent with Industrial Cleanup Goals for Florida.

6.1.6 Uncertainty Analysis Risk estimates are generally conservative values that result from multiple layers of conservative assumptions inherent in the risk assessment process. Quantitative estimates of risk are based on numerous assumptions, most intended to be protective of human health (i.e., conservative). As such, risk estimates are not truly probabilistic estimates of risk, but rather conditional estimates given a series of conservative assumptions about exposure and toxicity.

A thorough discussion of all potential sources of uncertainty in risk assessment is not feasible. In general, sources of uncertainty can be categorized into site-specific factors (e.g., variability in analytical data and exposure assessment) and toxicity and risk characterization assessment factors. Most toxicity- and risk characterization-specific uncertainties apply to all HHRA's equally in their impact on the calculated risk estimates. Common (not site-specific) sources of uncertainty and their potential effects on the magnitude of estimated risks are discussed here. Table 6-8 summarizes some of the sources of uncertainty that are common to all HHRA's. Site-specific uncertainties are normally discussed in the site-specific uncertainty section in an HHRA to provide perspective for the interpretation of the site-specific risk estimates.

Data Collection, Analysis, and Evaluation. A certain amount of uncertainty is associated with the representative nature of the data collected to complete the risk evaluation at each site. Additional uncertainties associated with estimating exposure result from the variance in sampling and analytical techniques. There are three general uncertainties related to data collection, analysis, and evaluation:

- nature and extent of contamination,
- adequate characterization of exposure areas, and
- differences between site-specific inorganic concentrations and background inorganic concentrations.

Nature and Extent of Contamination. The nature and extent of contamination is normally discussed in detail as part of the RI. The extensive sampling and analytical program of an RI should adequately characterize the types of contaminants present, the physical location of those contaminants, and the concentrations that are present. There is inherent uncertainty in the assumption that the nature and extent of contamination has been adequately characterized.

Adequate Characterization of Exposure Areas. Contaminated areas, specifically soil, are sometimes small relative to the area in which a receptor would potentially be exposed. Non-random sampling may be conducted in areas of known

or visible contamination. Because a receptor's exposure area may actually be larger than the area of contamination and a receptor's exposure would often be random, the non-random sampling may actually result in overestimation of exposures.

Differences between Site and Background Concentrations. A comparison between site-specific and background inorganic concentrations is conducted as part of the selection of HHCPs (Subsection 6.1.2). Both organic contaminants and inorganic analytes are commonly detected in surface soil and groundwater background locations.

Organics (e.g., pesticides) that are sometimes detected in background samples, which would be expected in an industrialized area such as NTC, Orlando, do not necessarily indicate that the inorganic concentrations in those samples do not represent background reference concentrations. Phthalates are also commonly detected in background samples. Phthalates are common sampling and laboratory contaminants, but sometimes cannot be conclusively associated with laboratory or sampling contamination and, therefore, are retained in the background data set. In summary, the presence of organic contamination in a particular background location does not necessarily indicate that the inorganic concentrations in that sample is not representative of inorganic reference concentrations. The use of the background sample data as a reference point for inorganics detected in surface soil and groundwater is generally considered appropriate based on carefully chosen sampling locations.

Selection of Chemicals of Potential Concern. Although a USEPA approach is criteria are used in selecting HHCPs (USEPA, 1989a), there are uncertainties in the general selection process based on the use of a risk based screening and comparison to inorganic concentrations at reference locations.

USEPA Region III Risk-Based Screening Table (October 20, 1995). USEPA Region IV prefers to exclude contaminants that do not contribute significantly to the risk from the risk calculations (USEPA, 1995a). The HHRA uses medium-specific RBCs that are calculated by assuming residential exposures and calculating risk-based levels in water (e.g., tap water) and soil (e.g., residential surface soil) using an acceptable cancer risk level of 10^{-6} and an HQ of 0.1 (USEPA, 1995a) as a risk

based screening for the maximum concentration of each contaminant detected in surface soil and groundwater, respectively. Since residential use is not an option at OU1 because of deed restrictions, the use of residential RBCs is a very conservative approach.

Background Screening for Inorganics. For a given inorganic analyte, the maximum reported soil or groundwater concentration at a waste site is compared to 2 times the average of the medium-specific concentrations in the background (Subsection 6.1.2) locations. This comparison is conducted as part of the selection of HHCPs. If the maximum site concentration is less than 2 times the arithmetic mean of the inorganic reference concentrations, the analyte is considered to be consistent with background concentrations. This approach is conservative in that it is likely to identify certain analytes as being inconsistent with background (including them as HHCPs) even though the distribution of concentrations onsite is very similar to that of the background dataset. This can occur when the average inorganic screening concentration at a reference location is less than the maximum detected value at the site being investigated. For example, a site-specific inorganic could be present at a concentration greater than the corresponding screening concentration, including it as a HHCP, but still be within the detected range of inorganic concentrations the reference locations. This is the result of natural variability for inorganic concentrations in soil. Therefore, it is quite possible that an analyte could have a concentration distribution at a site that is identical to the distribution of concentrations for that analyte in the background dataset, but also have a maximum detected concentration that is more than twice the arithmetic mean of the concentrations in the reference dataset.

Toxicity Equivalency Factors for Carcinogenic Polycyclic Aromatic Hydrocarbons. In selecting HHCPs (Subsection 6.1.2), the selection of a single PAH in a particular medium requires that the additional PAHs detected in that medium be retained as HHCPs even if the PAH is less than the available risk based screening level. This is a protective approach that is unlikely to underestimate risks.

Exposure Assessment. There are four major issues that contribute to uncertainties in the exposure assessment of most HHAs:

- land use,
- use of the reasonable maximum exposure,
- determination of the exposure point concentration, and
- exposure parameters.

Land Use. Generally, exposure scenarios associated with future land use are difficult to predict. However, deed restrictions will prohibit future residential land use at OU1. Therefore, the limits on future land use are more certain than in many other risk assessments.

Reasonable Maximum Exposure. The exposure assessments conducted in an HHRA can be characterized as RME. As such, the exposure estimates represent a mix of "high end" and average exposure parameter values that result in an exposure estimate that is unlikely to be exceeded in an exposed population. Because some of these parameters are functions of the behavior patterns and personal habits of the exposed populations, no one value can be assumed representative of all possible exposure conditions. Further, uncertainties associated with assigning single exposure parameters to a heterogeneous population, which includes both men and women and the young and the old, (e.g., body weight, surface area, and ingestion rates), are considered significant. However, the risk assessment incorporates assumptions or procedures that result in the estimate of an upper bound of risk. This type of exposure assessment tends to overestimate risks for the large majority of an exposed population. To address the most conservative exposure scenario available, the future resident (an RME) is normally evaluated in an HHRA.

Exposure Point Concentration. The EPCs used in the HHRA are the 95 percent UCL on the arithmetic mean concentration or the maximum reported concentration in a contaminated area (whichever is lower). In many cases there is a relatively small number of samples available, and the 95 percent UCL is actually higher than the maximum detected concentration of a contaminant. In such cases, the maximum detected concentration has been used to represent the exposure concentrations. Because the cancer risks and HI calculations theoretically evaluate risks for average concentrations, the use of the 95 percent UCL or the maximum detected concentration is considered a conservative estimate of exposure and, therefore, risk.

Exposure Parameters. The selection and use of exposure parameters contribute to the uncertainty inherent in a risk estimate. There are several exposure parameters that impact most risk assessments as described below.

Particulate Emission Factor. The derivation of the particulate emission factor that is used as an exposure parameter to evaluate exposure to particulates resulting from soil suspension by wind is described in Appendix J-6. The particulate emission factor (PEF) that is used to calculate the concentration of soil particles that a receptor may inhale is the same for multiple receptors (for example, the resident and excavation worker). However, it is likely that more soil particles would be suspended in air during soil excavation activities and, therefore, that an excavation worker would be exposed to greater concentrations of HHCPs associated with airborne soil particles than other receptors. Risk associated with inhalation exposures for the excavation worker may be underestimated in the HHRA. It is likely; however, that use of a PEF representing greater particulate concentrations would only result in additional risks of less than an order of magnitude. If risk estimates for the excavation worker are orders of magnitude below USEPA threshold ranges, the use of an excavation worker-specific PEF will not normally be evaluated.

Toxicity Assessment. Toxicity information for many chemicals is very limited, leading to varying degrees of uncertainty associated with calculated toxicity values obtained in IRIS or HEAST. General sources of uncertainty for calculating toxicity factors include extrapolation from animal to human populations, low to high dose extrapolation, short-term to long-term exposures, interspecies sensitivity variation, extrapolation from subchronic to chronic no observed adverse effect level (NOAEL), extrapolation from lowest observed adverse effect level (LOAEL) to NOAEL, amount of data supporting the toxicity factors (i.e., inadequate studies), consistency of different studies for the same chemical, and responses of various species to equivalent doses.

The identification of human carcinogens and non-carcinogens, based on animal data, is a primary source of uncertainty in the use of toxicity values. It is not certain that the identification of carcinogenic activity in an animal species means that carcinogenic activity in humans will occur. In some cases, the metabolic processes involved in carcinogenic activity in a particular organ in

animals may not exist in humans. Available evidence indicates that there are a limited number of substances that are classified as human carcinogens (USEPA Class A substances). The extrapolation of short-term to long-term exposures is also a component in some cases for the carcinogen dose-response values. The use of toxicity measures (e.g., RfDs and CSFs) introduces additional uncertainties. These parameters are generally based on animal studies, many of which are performed at high doses relative to the site-specific exposures that potentially could occur. These data require interpretation and/or extrapolation in the low dose area of the dose-response curve. The CSFs used in the risk assessment generally represent a "high end" estimate. The CSFs are the 95 percent UCL on the actual slope derived from the scientific data and, therefore, are likely overestimates of the potency.

Risk Characterization. A mixture of analytes is present in each media evaluated at NTC, Orlando. The USEPA's Guidelines for the Health Risk Assessment of Chemical Mixtures (USEPA, 1986) states that if sufficient data are not available on the effects of the chemical mixture of concern, or a reasonably similar mixture, additivity of effects for constituents of the mixture should be assumed. This assumption, according to USEPA, is expected to yield generally neutral risk estimates (i.e., neither conservative nor lenient). More recent guidance from USEPA (USEPA, 1992c) also references the Guidelines for the Health Risk Assessment of Chemical Mixtures, but further states that the assumption of additivity assumes independence of action and that if this assumption is incorrect, overestimation or underestimation of the actual multiple substance risk may occur. In calculating HI values, additivity is assumed, but in some cases the analytes in a mixture have significantly different toxic mechanisms of action and impact different organs. In these cases, the overall HI likely overestimates non-cancer risks.

General uncertainties associated with the collection, analysis, and evaluation of data; exposure assessment; toxicity assessment; and the risk estimation process are discussed in Subsection 6.1.5. Site-specific uncertainties that are important for the interpretation of the calculated risk estimates for surface soil, groundwater, and sediment at the North Grinder Landfill are discussed below.

- Some uncertainty is associated with the representativeness of the groundwater data collected to complete the risk evaluation at the North

Grinder Landfill. Generally, because the low flow method was used, turbidity in the unfiltered groundwater samples was minimal. However, the analytical data from some of the unfiltered samples may indicate high inorganic concentrations as a result of suspended solids.

- The arsenic CSF is a source of uncertainty in the HHRA because concentrations of arsenic that tend to be present in surface soil and groundwater in the area surrounding NTC, Orlando are high enough to consistently cause arsenic to be a significant contributor to cancer risks. The oral CSF for inorganic arsenic is based on dose-response data for skin cancer incidence obtained by Tseng et al. (1968). Individuals in this study were exposed to high levels of inorganic arsenic in drinking water (170 micrograms per milliliter [$\mu\text{g}/\text{ml}$]). Arsenic exposure was approximated based on estimates of water intake. Other exposure pathways contributing to total exposure, such as ingestion of fish, livestock, and plants were not assessed, potentially resulting in an underestimate of arsenic exposure. The oral slope factor was calculated using a model that assumes the dose-response curve is linear at low doses. Recent evidence suggests that low doses of arsenic may be largely detoxified by methylation, producing a non-linear dose-response curve (Goyer, 1991). In the Tseng et al. study, the normal detoxification pathways were probably overwhelmed; this, coupled with an underestimate of exposure, may have resulted in an overestimate of cancer risk. Therefore, cancer risk for the North Grinder Landfill may be overestimated. Based on the uncertainties associated with the arsenic CSF, risk management guidance (USEPA, 1988b) suggests that cancer risk may in be up to 10-fold lower than predicted.

6.1.7 Remedial Goal Options Those media with estimated incremental lifetime cancer risks above 1 in 10,000 or with a total HI greater than 1 are identified for OU1. These media are to be selected for development of media cleanup levels in accordance with USEPA Region IV guidance (USEPA, 1995a). Remedial goal options (RGOs) and available criteria are intended to provide the basis for the development of remedial alternatives in the FS, which follows the RI.

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Because no calculated risks exceed the stated USEPA criteria for RGO development and site concentrations are consistent with applicable Florida Cleanup Goals, no Remedial Goal Options have been identified.

7.0 ECOLOGICAL RISK ASSESSMENT

An ecological risk assessment (ERA) was conducted as part of the RI conducted at the North Grinder Landfill (OU 1). The purpose of the ERA was to evaluate the potential for adverse effects to ecological receptors at the North Grinder Landfill (OU 1) at NTC, Orlando, and to ensure that the remedy selected for this site addresses all ecological exposure pathways and contaminants of concern.

The results of this ERA will be used in conjunction with other information gathered during the RI to evaluate the need at OU 1 for various components of the presumptive remedy for municipal landfills (USEPA, 1993b), which include:

- Landfill cap
- Source area groundwater control
- Leachate collection and treatment
- Landfill gas collection and treatment
- Institutional controls

The primary objective of this assessment is to determine if the landfill soil cover poses a risk to ecological receptors. Potential risks from exposure to leachate and landfill gas are also addressed.

Ecological habitats and potential ecological receptors are summarized below, followed by a discussion of chemicals detected at the site, potential ecological exposure pathways, ecological effects, and ecological risks at OU 1.

7.1 SITE CHARACTERIZATION. (This Section has been omitted because it is considered nonessential for this submittal).

7.2 HAZARD ASSESSMENT AND CHEMICALS OF POTENTIAL CONCERN. (This Section has been omitted because it is considered nonessential for this submittal).

7.3 EXPOSURE ASSESSMENT. Following USEPA's directive on presumptive remedies for CERCLA municipal landfill sites (USEPA, 1993b), exposure pathways that are addressed by the presumed remedy need not be evaluated in the risk assessment. The only potential ecological exposure pathways are those associated with contaminants in surface soil, surface water, and sediment. Under the presumed remedy, no contact with landfill materials is assumed (USEPA, 1993b). As previously discussed, contaminants from the landfill have not migrated to surface water or sediment, and therefore, from an ecological risk perspective, additional measures for source area groundwater control and leachate collection and treatment do not appear to be warranted. Groundwater, surface water, and sediment are not considered further in this ERA.

Currently, much of the landfill is paved, therefore, it is unlikely that ecological receptors would be exposed to landfill constituents. In unpaved areas, small mammals and birds may come in contact with landfill cover soil by incidental ingestion, direct contact, and inhalation. Fur, feathers, or chitinous exoskeleton likely limit the transfer of contamination across the dermis; therefore, significant exposures related to dermal contact are not expected. Exposures related to inhalation are not evaluated because this pathway is generally considered an insignificant route of exposure except in unusual circumstances, such as following a spill or release. Because of the limited habitat available at OU 1, incidental ingestion and food chain exposures for larger predatory species are unlikely to be significant.

In unpaved areas, plants and soil invertebrates (e.g., earthworms) may be exposed to chemicals in surface soil via direct contact and uptake into tissue. Soil invertebrates may also be exposed via ingestion of contaminated soil.

At the North Grinder landfill, significant contact with subsurface soil is considered unlikely for the majority of ecological receptors. It is possible that animals, including a number of small mammal species, could burrow into landfill material and be exposed. However, the likelihood of this is limited due to the developed nature of the site and the lack of a slope/hillside or soil mounds which are locations where animals usually tend to burrow.

Future use of the site is projected to be recreational (ABB-ES, 1996) and therefore it is possible that in the future, pavement may be removed from the site. Soil data from samples collected beneath pavement were included in this ERA, and therefore, even if pavement and/or buildings are removed and additional surface soil becomes exposed, future risks are unlikely to differ greatly from risks evaluated in this ERA.

Risks to terrestrial wildlife (small mammals and birds), plants, and soil invertebrates are evaluated in this ERA. These receptors are conservatively assumed to be exposed to the maximum detected concentration of each CPC (Table 7-1).

7.4 EFFECTS ASSESSMENT. Effects to small mammals and birds are measured by means of protective contaminant levels (PCLs) which are calculated using laboratory-derived toxicity data and receptor-specific exposure parameters. Toxicity data based on ecologically-relevant endpoints, such as reproduction, were used to derive these PCLs. The PCLs are intended to be protective against population-level effects in ecological receptors. The derivation of PCLs is discussed in Appendix K.

Toxicity data for plants and invertebrates were selected to be protective of the survival and reproduction of these ecological receptors. A discussion of the plant and soil invertebrate toxicological values is provided in Appendix K.

7.5 RISK CHARACTERIZATION. To evaluate potential risks to vertebrate, invertebrate, and plant populations from exposure to landfill cover soil, exposure concentrations were compared to vertebrate PCLs, and to invertebrate and plant toxicity values (Table 7-1).

The results of this comparison indicate that vertebrate and invertebrate receptors are not at risk from exposure to concentrations of analytes detected in surface soil at OU 1. In addition, terrestrial plants are not at risk from exposure to organic analytes detected in OU 1 soil. Maximum concentrations of chromium, mercury, silver, vanadium, and zinc exceed their phytotoxicity screening values.

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With the exception of chromium, these analytes only slightly exceed their benchmarks, suggesting that the likelihood of adverse effects to plants from exposure to these inorganic analytes is low.

The maximum chromium concentration exceeded its respective phytotoxicity benchmark by a factor of 27, indicating that plants exposed to the maximum concentration of chromium may potentially be adversely affected. Chromium was detected in all fourteen surface soil samples collected at the landfill. The arithmetic mean of all concentrations calculated for chromium is approximately 7.1 mg/kg (which exceeds the phytotoxicity value by a factor of 7). The highest detected concentrations of chromium (15 mg/kg, 16 mg/kg, 27 mg/kg, and 10 mg/kg) in surface soil were detected in the unpaved, northwestern portion of the site at sample locations U1S00100, U1S00200, U1S00700, and U1S00900 (respectively). The remaining soil locations had detected concentrations of chromium ranging from 1 to 5 mg/kg.

The phytotoxicity benchmark used for chromium (1 mg/kg) was obtained from Will and Suter (1994). As discussed in Appendix K, phytotoxicity benchmarks were derived to represent the 10th percentile of the Lowest Observed Effects Concentrations (LOECs) for growth and yield endpoints. Since the number of studies included in the authors' review (n=7) was less than 10, the chromium phytotoxicity benchmark equal to the lowest LOEC was used, and a confidence level of "low" was assigned by the authors to the benchmark. The lowest LOEC was based on a decrease in fresh shoot weight for lettuce as an endpoint; therefore, exceedance of this value indicates that growth of plants in soils at concentrations in excess of 1 mg/kg could potentially be impaired. Thus, plants in the grassy area in the northwestern portion of OU 1 could potentially be adversely affected. Will and Suter (1994) recognize that the derived benchmarks are conservative means for estimating population- or community-level impacts. The conservative nature of the benchmarks, combined with the fact that the vegetation at OU 1 is limited to planted grasses and ornamental shrubs, indicates that plant populations at OU 1 are unlikely to be adversely impacted by chemicals of concern in surface soil.

The results of this risk assessment indicate that ecological receptors are unlikely to be at risk from exposure to contaminants in surface soil at OU 1.

7.6 UNCERTAINTIES. There are many uncertainties associated with the conservative approach used in the NTC, Orlando OU 1 ERA. General uncertainties associated with the risk assessment process are provided in Appendix K, Table K-8. Based on the findings of no substantial risk, and that the most conservative assumptions were used in the ERA, further discussion of uncertainties is not presented.

7.7 SUMMARY AND CONCLUSIONS OF ERA. The findings of this ERA indicate that soil invertebrate and small mammalian and avian receptors are unlikely to be at risk from exposure to analytes detected in OU 1 surface soil. It is anticipated that no predatory mammals or birds, or rare and endangered species, would inhabit the site. Concentrations of chromium in surface soil, particularly in the northwestern portion of the site, exceeded the terrestrial plant screening value for this analyte. However, based on the nature of vegetation present at the site (planted grass and ornamental shrubs), risks to terrestrial plant populations are unlikely.

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